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REMINISCENCES OF EARLY MARINE STEAM ENGINE CONSTRUCTION AND STEAM NAVIGATION IN THE UNITED STATES OF AMERICA FROM 1807 TO 1850.

BY CHARLES H. HASWELL, ESQ.

[The following very interesting reminiscences of Mr. Haswell were read at the thirty-ninth session of the Institution of Naval Architects, March 31, 1898, and are here printed for the benefit of our members and associates, who will undoubtedly find them full of valuable facts which, in connection with the advances of engineering science and mechanical improvements, start the curve of progressive work of which even the most sanguine can not, as yet, plot the upper points.—ED.]

Marine steam engines of the primitive construction, and down to 1822, were of the vertical crosshead type, connected with sliding clutches directly to the water-wheel shafts, and also geared to a shaft with a fly wheel at each end of it; the object

of the connection, that of enabling the water wheels to be disconnected, and the engine operated independently and solely to feed the boiler and operate the bilge pump when the vessel was at a pier or anchored, as independent steam, feed, bilge and fire pumps were then unknown. The steam and exhaust valves, if puppet, were operated by the hand gear of Beighton; when otherwise, the long slide valve was used.

This type of engine, with the crosshead, connecting rods, cranks and shafts of cast iron, the key, crank and pin holes cored and cast in, was wholly used until about 1822, when the vertical overhed beam was introduced, and when the horizontal or inclined engine was introduced the short slide valve was resorted to, except in the southern and western waters, where the lever poppet, operated by a cam, was wholly used.

The boilers, with the exception of the very first few, which were plain cylindrical, set in masonry, were of copper plates of the design termed "D. and Kidney Flue," having but one furnace, full width of inner space of front, the flame and gases of combustion leading through a flue of about two-thirds width of furnace into a back connection, and from thence into a return flue, which, from the outlines of its transverse section, was termed a "kidney flue," and from thence to a short vertical flue at the back of the furnace, and then extending up to the shell of the boiler, in a short shoulder of which the base of the smoke pipe was set. The cause of this convexity to the inner side of the main flue, and the indentation given to the inner side of the other, was because the curved surfaces rendered socket bolts less necessary, with the limited steam pressure of 15 pounds or less per square inch.

On southern and western waters, where non-condensing engines were alone resorted to in consequence of the waters of the rivers being too turbid for the continuous operation of a condenser, wrought-iron cylindrical boilers alone were used, and the character of the iron was such that the plates were cold riveted; generally internally fired, in some case externally, and it was not until about 1820 that marine boilers were constructed of iron in eastern waters.

Boiler Plates.—These were punched manually by the aid of a long wooden lever, on which four men exerted their force, and as the location for the punch was directed only by the eye of the operator, the spaces were frequently irregular, involving pinning, in order to bring the holes as nearly opposite as practicable, and hence the plates were frequently strained and the rivets set at an inclination. All of the latter were hand made, but at the east were driven hot.

Blow-offs.—These were not attached to boilers until steam navigation was well advanced. The exact period is not now ascertainable, probably about 1822. The boilers of steamboats on the bay and river routes, with the low pressure, and the consequent low temperature, of steam with which they were operated, did not involve the necessity of the frequent blowing off of saturated water from their boilers, and the water was allowed to run out of them at the end of each passage, and then refilled with fresh water. In consequence of this neglect of blowing off, and the imperfect manner in which the plates of a boiler were riveted, a boiler at the end of a trip in wholly or even partially salt water would be loaded in its seams and joints with incrustations and stalactites of salt, to an extent that involved their being hammered and scraped off at the termination of the route. Felting of a boiler was unknown.

Cranks and Crank Pin.—The shaft holes of cranks were octagonal, and the latter were secured to the shaft with flat keys, the interspaces fitted with a cement of iron borings and sal ammoniac; and as the distance between the centers of the crank, from the varying shrinking of the metal and the casual settling of the cores, would differ from that of the exact required length of half stroke of the piston, the pin was forged with two longitudinal centers, one for the hub and the other for the eye of the crank, and when the pin was fitted and seated, it was held in position by a key in its end, which protruded beyond the eye of the crank.

Finishing.—So deficient were the facilities of lathes, planers, slotters and drills, that "black work" of engines, as it was termed, was the prevailing finish. The connecting rod of a large verti-

cal beam engine in the *Victory* was wholly finished in the smith's shop, its body, after forging, being dressed by swaging, the key holes drifted, and the ends and straps dressed with a flatter on an anvil and a horse file.

Cylinder Piston Packing.—This consisted of hemp gaskets, and, if the safety valve of the boiler was not raised during the initial raising of steam, the steam around the chimney flue would become so dry as to char the wood blocking between the ribs of the piston, and also the piston packing; hence, lead pipes, through which the gaskets were drawn, were resorted to.

Counters, Indicators, Salinometers, Brine Pumps, Steam and Vacuum Gages, Metallic Packing, Whistles, and Oil Cups, other than the one in the cylinder head, by which the piston was lubricated on its exhaust side, were unknown.

Cut-offs.—These were operated by a cam on the water-wheel shaft, hence, upon the closing of the cut-off valve, all the steam in the pipe between the valve and in the side pipe up to the steam valve, was added to that expended without any effect that compensated for its flow, and, as a result, it was sought to save this expense, and Robert L. Stevens, of Hoboken, N. J., designed and successfully introduced the cutting off of the steam directly by the steam valve.

Compound or Woolf Engine.—In about 1824, James P. Allaire constructed the steamboat *Henry Eckford* with a vertical cross-head compound engine, the center shafts geared to the water-wheel shafts; but, in the absence of a receiver the mutual operations of the cylinders were only at the extreme of the opposite strokes of their pistons. Soon after, and up to 1828, he constructed five other boats, namely, the *Sun, Commerce, Swiftsure* and *Pilot Boy*, with like engines, and the *Post Boy* with an overhead beam engine, the cylinders being set at its opposite ends; but, as this type of compound engine operated at the moderate pressure of but twenty-five pounds per square inch, it did not attain such an effect as to justify the increased cost and weight of two cylinders and their connection, and its further construction was abandoned.

Steam Chimney.—In 1827, James P. Allaire, of New York,

invented the steam chimney; the original design being that of two cylinders of boiler plate, one within the other, connected and closed at both ends, the interspace being about 5 inches in width, with a vertical diaphragm, connected near its upper end to the outer shell above where steam was admitted from the boiler, through two or more connecting pipes, which served also as fastenings and to hold the chimney in position. This diaphragm led down to within a few inches of the bottom of the chimney, and the steam was inducted down and under it, then up and around the inner cylinder, and from thence to the steam pipe opening in the top; thus the steam deposited its contained water in the chimney, to be vaporized by the heat at the base, and received also heat from that ascending the chimney, hence a material economy of fuel was attained with the advantage of obtaining dry steam. Boilers at this period did not foam (prime); the great proportionate volume of water, its area at the water-line, and the moderate heat in the furnace from wood, with but a natural draft, precluded it.

In 1828, the engine of a large steamboat, the *Chief Justice Marshall*, on the route from New York to Albany, broke down by the breaking of the head of her piston rod at its insertion into the crosshead socket; the crosshead, both connecting rods, and a center crank were broken, and in four days new castings from the builder's patterns were made, the piston rod repaired, all fitted, and the engine ready for operation.*

In this connection it is to be considered that neither the eye of the crank was reamed nor the key holes of the rods slotted; they, the crank eye, and the ends of the rods, were submitted only to the operation of a coarse file.

In the attachments to engines and boilers the steam gages were constructed in the smith's shop, and consisted of an iron tube half an inch in diameter and four feet in length, bent, with one of its legs fifteen inches in the clear in length, and in the other the balance of its length was filled with mercury, on which was placed a light pine rod, the rise and fall of which, shown on

* Witnessed by the writer.

a tin plate divided and numbered in inches, designated the pressure of the steam in pounds per square inch.

Steam navigation, up to the latter part of 1829, was confined to Long Island Sound, the southern and western rivers, and Canadian lakes and rivers, with a single passage of a steamboat from New York to Philadelphia, the *Phœnix*, in 1807, and one on the route from Havana to Matanzas, and one from Charleston to Savannah. In 1819, the auxiliary steamer *Savannah*, of 380 tons, steamed and sailed from Savannah to Liverpool, she being the first steamer to cross the Atlantic Ocean.

In 1825, Mowatt Bros., of New York, owners of the steamboat *Henry Eckford*, attached a loaded barge to her, and transported it from New York to Albany; this was the first essay of steam towing, and, although its insufficiency and impracticability were generally predicted, the enterprize proved to be a great and lasting success.*

In 1826, a fan blower was first introduced under the grates of the boilers in the steamboat *North America* of the Messrs. John C. & Robert L. Stevens.

In 1828–1829, the rivalry for speed between the steamboats plying on the route from New York to Albany was so great that, in the design of the boats, their beam was disproportionate to the weight of the engine, boilers and deckhouses above, and they proved unstable. In order to reduce this condition, large logs of light pine wood with sharp ends were firmly suspended under their after wheel guards and depressed for half of their diameter below the water line, and in operation they measurably improved the stability of the boat.

In 1830, the patent of the steam chimney of Mr. Allaire was invaded, and its operation simplified by making the double cylinder an integral part of the boiler, open at its lower end, and extending to such a height above the boiler as to give the necessary surface to superheat the steam, and the required height and volume of steam space measurably to arrest foaming, by admitting the subsidence of the water, physically borne with the steam in its flow to the steam pipe.

* Witnessed by the writer.

Gongs for the engine room were unknown, and in many of the boats, when the pilot was in his house (if there was one) or on the deck over the engine room, he would signal to the engineer by the strokes of a stick or cane upon the floor of the house or deck.

All boats, of course, carried bells, and by them all notices of departure and of arriving were made known, and all salutes between boats were given by their bells. To blow steam, as is now done by a whistle, was intended and held to be a challenge or an insult.

Fuel, up to the year 1836, was wholly of pine wood, at which period some owners of steamboats commenced experimenting upon the practicability of using anthracite coal. A steamboat on her route of six or more hours could not have the capacity in her fire room to contain all the wood required, and was compelled to pile it upon her side houses; and such boats as were on a long route, as from New York to Providence, were compelled to invade their upper deck with wood, and upon leaving the city had somewhat the semblance of a floating woodyard.

In 1836 James P. Allaire commenced the running of a steamboat, the *David Brown*, a light-built river boat with deckhouses and promenade deck, from New York to Charleston and return, the enterprise being almost universally held to be utterly impracticable. It was successful, however, and soon afterwards he built two other and larger boats for the same route, and from that period coastwise steam navigation was held to be so practicable that various lines to other ports were established. The *David Brown* was fitted for this new service with planking under her water-wheel guards closely joined and caulked, extending from the inside of string piece to the light water line, which shielded the guards from being forced up by a sea. This device, after several essays at a proper term, is now known as the sponson.* In some cases on coast routes, instead of a closed shield open slatting was resorted to.

1837.—The first propeller steamer was introduced.

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* This term was given also by the writer.

1838.—Phineas Bennett designed, patented and introduced, in the steamboat *Novelty*, plying on the Hudson River, a vertical cylindrical boiler in which a hermetically closed furnace was supplied with air by a pump, and all the gaseous products of combustion of the fuel were driven into the steam room of the boiler; the object of this design was to increase the generation of steam and reduce the proportionate area of heating service.* The boiler, after a short period of service, was removed.

Soon afterwards he introduced the design into a vessel built to ply between New York and Liverpool, under the conditions with her builder that, if the design proved to be acceptably successful he was to be paid for the entire plant of engines and boilers and his services, but if not successful he was to remove the entire plant, and at his own expense, without any remuneration whatever. The engines and boilers were completed and operated, but they were not paid for by the builder of the vessel, and the boilers were soon after removed and replaced with others. In consequence of the ashes borne into the valve chests and cylinders, and the evaporation of the oil of lubrication by the dry heat of the steam, the valves were rapidly worn, and the cylinder pistons shrieked to a degree that would have rendered the design very objectionable, even if it had been successful in other points.

Captain John Ericsson arrived in New York in this year, and in 1842 he designed and directed the construction of the engines and propeller for the United States auxiliary bark-rigged steamer *Princeton.*

1839.—Anthracite coal was introduced as fuel for steamboats, and, to aid its combustion when a high pressure of steam was required, a fan blower, driven by a belt from the water-wheel shaft, was first resorted to, but soon afterwards a small independent engine was resorted to, connected by a belt to the blower.

Anthracite coal was soon afterwards first burned without auxiliary draft in the open furnace of a steam boiler.

1840.—Wrought-iron shafts were first made, the construction

* Witnessed by the writer.

varying wholly from that of the present period; thus, iron bars from 2.5 inches to 3 inches square and of the greatest attainable length were laid up with a square section, the abut ends breaking joints with the other bars; hence the solidity of a section of the mass was only subjected to any imperfection arising from their ends not being wholly welded, by the percentage of the section of one bar to the whole number; and of all the shafts made up to the period included in this paper but one was broken, and that in consequence of its being insufficient in diameter for the stress to which it was subjected, and this result was foretold when the diameter of the shaft was reduced from that given in the specifications.

1842.—The first steam frigates for the United States were constructed.

1846.—Captain John Ericsson applied a surface condenser to the engine of a revenue cutter, and in 1848 Pierson designed an improvement, which was further improved by Chief Engineer William Sewell, of the Navy, and the perfected instrument is now in general, if not in universal, use.

1848.—The *Atlantic* and *Pacific*, of the New York and Liverpool S.S. Company, "Collins Line," were constructed in this year, and in July, 1850, the *Atlantic* made the then quickest passage between New York and Liverpool, it having taken but ten days and fifteen hours. The *Arctic* and *Baltic* of the same line were launched.

1850. Horse Power.—It is wholly impracticable to obtain the consumption of fuel per indicated horse power in early steam engineering, as engines were not fitted with counters or indicators and the wood was not weighed. In 1840, with auxiliary or blower draft, and in the absence of counters and indicators, it was computed by weighing the coal consumed, and held to be about 5 pounds, and the velocity of the river boats from 8½ statute miles in 1816, increased to 19 miles.

ELECTRICAL PROPULSION FOR TORPEDO BOATS.

By Charles T. Child.

[Contributed.]

The progressive evolution of the modern torpedo boat from the spar and bomb craft of the American civil war has reached its apparent limit along the lines of its more recent development. The steam launch making 7 or 8 knots has grown into the 30-knot, sea-going torpedo boat, armed powerfully for offense with automobile torpedoes and carrying a few light guns for defense. To attain the high speeds demanded in a torpedo attack everything has been sacrificed in the design of such boats to the necessity of floating the most powerful machinery in the lightest hull. The results attained challenge admiration when speeds and horse-powers alone are considered, but the craft themselves are adapted to the true tactics of torpedo warfare only in the one particular of speed. When the far more important qualities of silence, invisibility and safety are considered, it is evident that the steam-driven boat enjoys none of them, and that little more can be expected than has already been attained in any of these directions. It is true that the steam turbine seems to hold out possibilities of somewhat higher speeds, but even with the turbine, in boats of small size, it is not likely that any very great increase of speed will be made. Of course, if the boat is made larger, higher speeds may be attained, and it does not seem impossible to reach even such a speed as 40 knots with boats of 300 or 400 tons, but the natural question arises as to whether a gain in speed at the expense of secrecy—for the bigger the boat the easier it is to see—is advisable, and whether such vessels should have a place in torpedo maneuvers.

The torpedo boat is simply the expression of the principle underlying all strategy—the infliction upon the enemy of a

vital blow, costly to him in life and property and terrifying in moral effect, at the least cost in property and life to the attacking party. In other words, a combat between a torpedo boat and a fighting ship means that a few men in a little, inexpensive vessel take desperate chances to destroy many men in a large, costly vessel. If the danger of detection and annihilation to torpedo boats be minimized, the value of these vessels will be enormously enhanced. The nation owning a swarm of these wasps of the sea could make its coasts safe from attack and erect a barrier of terror that the stoutest sailor would not dare to pass. What chance would a battle ship have if simultaneously attacked by five or six boats of say 25 knots speed, each armed with automobile torpedoes? It would doubtless sink some torpedo boats, but it would as certainly be destroyed. Assuming, then, that a proper theory of torpedo attack is to risk as little as possible, and to make assurance sure by launching a number of boats at once against an enemy so as to divide his fire, it is well to see how the present craft plays its part under such circumstances before discussing the radical innovation which is proposed below.

In the first place it ought to be said, in justice to the torpedo boats of our Navy, which have been maligned by thoughtless critics for what they did and did not do in the recent war, that a torpedo boat is neither a cruiser, a dispatch boat, a yacht or a coast-guard ship. When highly specialized and necessarily delicate structures such as these are put to work doing duty for which they were never meant, day in and day out, with no base for repairs, no chance to get fresh water and absolutely no fit accommodations for their personnel, it is a matter of wonder and congratulation if all of them are not utterly ruined.

It may be laid down as an axiom that a boat built for torpedo service has to be so specialized as to be unfit for any other duty. The requirements are speed, silence, invisibility, quickness in maneuver, and the smallest possible crew. A sea-going, cruising torpedo boat is a sort of anomalous contrivance, developed out of the struggle for speeds, and is not, properly speaking, a torpedo boat at all. It is not expected to make torpedo attacks on

the high seas. They are directed at blockading vessels, ships lying in a harbor, and, in general, at vessels near shore and not going at full speed.

For the boats to be invisible they must be small. In the case of steamboats the visibility is heightened by the smoke and the stacks, while the chances of flaming funnels under forced draft are very good. These convert a torpedo attack into a sort of marine torch light procession, considerably more dangerous to the attacking party than to the attacked.

Silence is simply an impossiblity with a steam craft. The engines will rack and jar, the fans will purr, and the steam, lashed up under the excitement of an attack, will probably blow off.

From all these considerations, then, it is seen that steam torpedo boats making an attack at night (it is needless to say that a torpedo attack in daylight is suicidal folly) will have to run the gauntlet of no less than four dangers of their own making. The enemy is keeping a vigilant look-out and sweeping the water with his search lights. The boats must slip into their striking distance—a few hundred yards—without discovery. Suddenly a shower of sparks from a funnel, a hiss of high-pressure steam blowing off, a roar of fans and light engines running at furious speeds proclaim the presence of boats and the location of one of them. That one, at least, is apt to be immediately destroyed.

Seeing, then, that the steam-propelled boat has certain vital defects, is it not possible to imagine a vessel free from the dangers that beset the present-day torpedo boat? Cannot another motive power, simple in its application, powerful and silent and controllable, take the place of the snarl of water-filled tubes, the furnaces fanned to destructive heats, the complex engines with their multitude of reciprocating parts flying at fearful speeds under the impulse of high-pressure steam, the ghastly infernos of fire rooms where suffocating men run risks of a dozen kinds of death even in a peaceful cruise? The purpose of this brief sketch is to show that this can be done with that certainty of success that should warrant the attempt.

Let it be assumed that a boat of moderate size has its boilers, coal and engines replaced by accumulators and electric motors.

It is perfectly evident that if such a boat can show the speed of the steamboat it is superior to it in all the essentials of silence, invisibility and maneuvering power described above, as well as in the smaller crew required and the consequent smaller risk of life in an attack.

To illustrate the present possibilities and limitations of such an application of electric power it is easiest to take a concrete case and show what results could be obtained with the motor equipment.

A boat about 140 feet long, having a beam of 14 feet and a draught of 5 feet, will displace, light, 110 tons, and carries, normally, 30 tons of coal. If 45 tons is allowed for the weight of the hull, ammunition, crew, stores, etc., there is left 95 tons, or 213,000 pounds, for the electrical equipment.

To attain a speed of 22 knots about 1,500 horse power will be required. As the torpedo boat goes at full speed only at the instant of attack, the motors installed should be such as to work economically at lower speeds, should weigh as little as possible, and should be worked up to their utmost maximum of output for the rush of attack. Without going at length into questions of motor design, it may be said that four motors, each developing 400 horse power at its maximum, are indicated. These, by careful design, using laminated iron in the fields, may be reduced to a weight of 6,500 pounds each, or 26,000 pounds for the four. This leaves 187,000 pounds for the battery, circuits and controller or switching devices. Allowing 12,000 pounds for these latter, and 175,000 pounds for the battery, what performance can be expected of the boat?

In a concourse of automobile vehicles held in France during the past summer a number of types of light and very powerful accumulators were brought out and given a hard, practical, service test by a commission appointed for that purpose. Taking the figures given by them for the performance of the average cell, the 175,000 pounds of accumulators will maintain an output at the screws, the losses in conductors and motors being included, of about 140 horse power for twenty-four hours; 300 horse power for ten hours; 520 horse power for five hours; and

2,000 horse power for one hour—a power that would give a rush speed of as much as 25 knots. At the twenty-four hour discharge rate the speed would be about 9 knots and the cruising radius about 216 nautical miles.

From these figures it is perfectly evident that this craft is fitted to discharge the normal functions of a torpedo boat with entire satisfaction. It has sufficient range at slow speed to travel to some distance from its base. It has a rush speed equal to or greater than that of a steam-driven vessel of the same size. But, above and beyond all this, it has silence, secrecy of movement, absolutely instantaneous and certain control, and other points of advantage so great as to far outweigh the disadvantage of a short radius of action. A comparison of the operative efficiency of the two types, steam and electric, may be interesting.

A steam vessel of this class would carry two officers and about eighteen enlisted men, a total of twenty lives. The electric boat would need only enough men to launch the torpedoes, one officer and five men at the outside. The cost of the boat would be about the same with either system of propulsion. From this it is seen that the risk of property in an attack is the same in the two cases, while the risk of life with the electric boat is far less, the destructive and offensive powers of the electric craft being the same or greater.

It will be at once conceded that a boat without stacks, without smoke, without the possibility of a flaming funnel, is less visible and less apt to attract the attention of the attacked ship than one of the ordinary type. In the matter of silence there is no high-pressure steam on the electric boat, no boiler tubes to burst and vomit up a small volcano of ashes and fire and steam through the stack, no fans that cannot be stopped during an attack (these would be ventilating fans, of course), no racketing reciprocating engines penned up in a sheet-steel sounding box. It slips through the water in silence and darkness, its low freeboard having no other projections than the conning tower and signal mast.

In the conning tower, or whatever corresponds to a conning tower on a torpedo boat, is the steering wheel and a "controller,"

precisely similar to those on electric street-car platforms though somewhat larger. With the handle of this in one hand and the steering wheel in the other the officer in charge of the electric boat has the whole craft absolutely bridled. Every other man aboard may be put out of action and yet a successful run made. There is no transmission of orders—no excited shouting in the noise and steam and sweat of a reeking engine room—but only the instant and silent answer of the motors to the touch of the controller handle.

The storage battery and motors, both being intrinsically heavy, can be stowed in very small space, well below the water line, and a thin deck worked over the whole. The entire upper works of the boat might be shot away without putting it *hors de combat.* A single well-directed shot, unless it sunk the boat, could do no vital harm, because there is nothing to harm. Both battery and motors, being perfectly divisible, may be placed in numerous compartments, and the electric boat thus so divided that its chance of surviving injury would be greatly increased. The circuits are run in duplicate or triplicate. There are four or five controllers in different parts of the boat, and among the four motors one would always be left in service. A shot from an ordinary small rapid-fire or machine gun would not damage the motors, and if it wrecked a few cells of the battery they could be "bridged across" in a few seconds. Indeed, by using many small cells in parallel groups, the battery could be made to do its work even if well riddled with small shot.

To charge these batteries would take, ordinarily, four hours. In an emergency it might be done in one hour. They should be arranged to work at the standard pressure of the lighting and power circuits on the large naval vessels—80 volts—so that a boat could be charged from any full-powered ship. This could be done even in a heavy sea, as there would be no occasion for close approach, such as is required in receiving coal or water from the ship. A cable, which might be of any convenient length, would be the sole connecting bond between the vessels.

It has been shown that an electric boat risks fewer lives in an attack, has advantages of silence, invisibility and maneuvering

power, is less vulnerable and incomparably superior to a steam torpedo boat. The only advantage the latter can claim is cruising radius. Is this an advantage? There would never be any suggestion of using the electric boat as a dispatch boat or as anything but a torpedo boat. It is instantly ready for service. Once charged it can speed up to its highest velocity in a few seconds. It can be towed behind any steam vessel to the neighborhood of the enemy, and, once there, can work devastation impossible to any boat handicapped by the danger of being discovered and shot to pieces before it can discharge its torpedo.

This very rough sketch of the present possibilities of electric torpedo boats is not offered as a solution of the difficult problems involved in their design. It has been written with the hope that it may provoke discussion in which the apparent importance and value of this method of driving may be well ventilated.

BRITTLENESS PRODUCED IN SOFT STEEL BY ANNEALING.*

By John Edward Stead.

In a previous paper by the writer, on the "Crystalline Structure of Iron," it was shown that under certain conditions soft steel sheets containing between 0.05 per cent. and 0.12 per cent. carbon, on close annealing for forty-eight hours occasionally developed an extraordinary tendency to become most readily fractured on the application of a sudden blow, or when they were hammered or dished into shape.

It is the writer's object in the present note to discuss more fully this peculiarity, and to present further facts bearing upon the subject. This title of the paper referred to probably justified the supposition by practical men that the matter contained therein was of purely academical interest, and in all probability little notice was paid to it. As a matter of fact, it contained much that was of a practical character, and many facts relating to the treatment of steel which metallurgists would do well seriously to consider. It must be admitted, however, that there was given a considerable amount of matter about which the busy men in our steel works would not care to trouble themselves. This note is more purely of a practical character, written so that all working metallurgists may fully understand and appreciate the great importance of the question discussed.

In order to make the data presented complete, it will be necessary to recapitulate the main facts given in the previous paper which bear upon the development of brittleness in soft steel by annealing.

The Terms used to Describe the Structure of Iron and Steel.—In iron, and in almost all metals, bright polished surfaces, on being

* Paper read before the Iron and Steel Institute; Stockholm Meeting.

etched by suitable reagents, are broken up into irregular polygonal masses, and resemble more or less perfectly mosaic which has been laid with stones of no regular form. Each polygonal area in metals represents the section of a crystal, the true terminal angles of which at the time they grew or were developed not being able to form owing to mutual interference of growing contiguous crystals. These polygonal areas in reality represent the grains or crystals seen on any rapidly fractured surface of a metal.

Practical men commonly describe such fractures in steel of "coarse" or "fine" structure as "finely" or "coarsely crystalline," but the terms "fine" or "coarse grained" are also used. Some engineers call a fine structure "granular," and a coarse one in which large bright faces are visible as "crystalline." We must remember, however, that whether the crystalline grains in a metal are large or small, the metal as a whole is equally crystalline, the only difference being that there are a greater number of separate individuals in one case than in the other. The polygonal masses of irregular shape when completely isolated much more resemble grains than crystals, and it appears more reasonable to call them the former than the latter. To be more exact, the term "crystalline grain" correctly expresses their character. As long, however, as it is clearly understood what is meant by terms, it is not of great importance which is used.

In the remarks which follow the term "grain" will be used instead of crystal, and it must be understood to mean a grain the mass of which is crystalline, the molecular crystals of which it is built being all of same orientation in the whole of its mass.

It has been repeatedly proved that many cubic crystals of minerals possess the property of being split up more readily in some directions than in others, and these are always at right angles to and parallel with a cube face. It will be seen, then, that the number of directions in which a true cube crystal can be split must be three, all of which are right angles to each other. The property of crystals to split up in this peculiar way is what mineralogists call cleavage.

Iron crystallizes in the cubic system, and the crystalline mass of every separate grain in a bar of iron is more liable to split up

in these three directions than in any other. When we talk of the orientation of the crystals of a metal, we mean the direction of their cleavage planes, and their relation to each other in the crystalline granules of which the metal is an aggregation.

Now, these remarks may be considered as elementary, and probably by the younger members, who have had the advantage of a full scientific training, as superfluous; but we must not forget that there are thousands of good, practical, useful men who never heard of crystallography, and it is for their benefit they are made; and when it is known that, for all practical purposes at any rate, it is not necessary to know more of crystallography than what has been here given, it is to be hoped the men about our works will not have any difficulty in grasping such elementary truths.

Inter-Granular Weakness.—The introduction of the microscope and the application of the methods described by the writer for the micro-mechanical examination of sections of metal, now enable us to determine with almost certainty the exact seat of the weakness in a metal, and to determine its character.

There are two distinct characters:

The first, where the weakness is located between the grains of the metal, that is, where the grains join each other. When such a metal is broken up, the line or direction of the fracture follows the junctions of the grains. This character of weakness we call "inter-granular," that is to say, between the granules. Sometimes the grains of metal do not actually come in contact, but are separated by envelopes of substances which separate out when the metal solidifies or is slowly cooled.

Professor Arnold's very beautiful researches on the influence of small quantities of impurity on the mechanical and structural properties of gold and copper have shown us many instances of such granular envelopments, and the researches of Osmond and myself have fully confirmed that gentleman's work.

On testing mechanically the small polished and etched micro-sections of such classes of metals, by placing them face downwards on a dished block of lead or other metal and striking them with a blunted center punch in the middle portion of the back,

so as to effect a partial or complete fracture of the specimen, and when the now broken section is re-examined under the microscope, the line of fracture almost invariably will be seen to traverse through the foreign matter between the grains.

The alloy of copper with a very little bismuth in which the grains of copper are enveloped with a brittle constituent is an excellent example of inter-granular weakness.

Professor Arnold has found that occasionally in steel castings the grains are more or less enveloped with an easily fusible scoriaceous matter, and the writer has proved, as was rightly assumed by Arnold, that the line of fracture actually follows the scoriaceous envelopes. The hard white and brittle envelopes of carbide of iron which surround the grains in steel containing above 1 per cent. of carbon, are the principal lines of weakness, and it is through the center of these brittle envelopes the fracture mainly travels when the steel is broken.

There is another character of inter-granular weakness, in which, so far as we can see at present with the appliances at command, there is weakness, yet no envelope of a brittle constituent is present. This is particularly marked in certain annealed steels containing phosphorus. Professor Arnold believes that the crystalline grains in the mass of such metal on cooling contract unequally, and tend to draw apart, leaving the junctions not perfectly jointed, or in a state of unnatural tension. Whatever the cause may be, it certainly happens that in such material the fracture follows mainly the granular junctions.

We see, then, that inter-granular weakness may be divided into two main classes:

1. When brittle matter foreign to the character of the mass of the grains envelops them.

2. When the brittle envelope is absent and the grains, from some cause not clearly demonstrated, are not perfectly cohesively united.

Inter-Crystalline Weakness.—The second character of weakness in metals is that in which the weakest line is not between the grains, but is that represented by the true cleavage planes through the mass or body of the grains. Example was given in

FIG. 1.

FIG. 7.

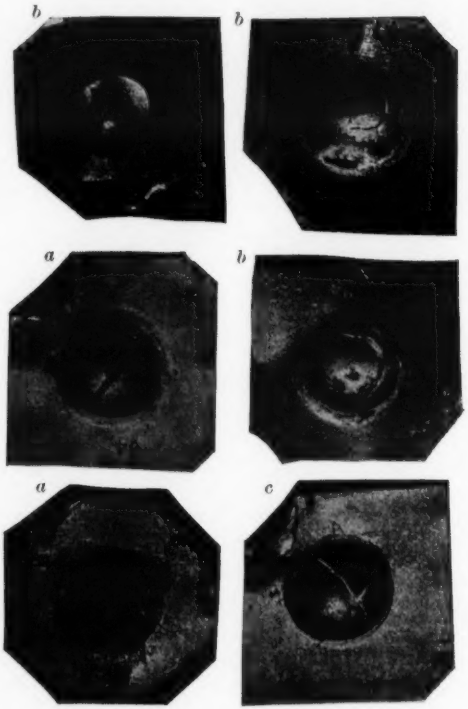


FIG. 8.

the paper read at the last meeting of cubical forms which had been split from a large crystalline grain of phosphoretted carbonless iron. Since then almost pure iron with grains measuring about 1 inch across have been obtained, which were with almost equal ease split up into similar forms.

As the line of fracture, on mechanically testing a mass or aggregate of crystalline grains, invariably passed through the mass and never followed the junctions of the grains, we have called this character of weakness "inter-crystalline," as the fracture passes between the molecular crystals of which the grains are built.

It has been found, when the unpolished cleavage faces of split-up rectangular masses of nearly pure iron are etched with nitric acid, that perfectly square portions of the iron are dissolved away, leaving more or less minute pits or recesses, and these are formed equally on all the six faces. This is very strong evidence that pure iron consists of cubic crystals and not octahedra (Fig. 1 which is magnified 200 diameters).

It has also been found that in a coarsely granular piece of iron, after it has been polished and etched by nitric acid, the different grains reflect light at varying angles. On examining such a plate, held directly in front of the eye, when we have our back to the source of light, such as that from a window, we find that certain grains appear brilliantly illuminated, whereas others vary in brightness, and that on slightly moving the specimen out of its vertical plane the brighter grains become dark, and the dark grains bright, and every movement causes a change.

We find that the grains which reflect back again the rays of light which fall vertically upon them are those which can most readily be broken up by a percussive blow directed through a blunt point behind it, and the fractures usually cross at an angle of 90 degrees. The same grains on deep etching are those which give the most perfect square cavities, readily seen when examined under the microscope. From all this evidence we know that the molecular crystals in these grains have their surfaces parallel with and vertical to the cut surface of the iron section.

In the grains which reflect the rays of light when the surface

of the specimen is moved in the manner just described, the faces of the molecular crystals are at an angle more or less acute to that surface. All this is easily followed by the aid of a simple diagram.

Fig. 2 represents diagrammatically the position and orientation of the molecular crystals in a few contiguous grains *A*, *B*, *C* and *D*. The little squares in each, tilted at various angles, represent the manner in which the little molecular cube crystals may be oriented in a vertical section of pure iron.

In *A* the cubes have their upper faces parallel to the surface.

In *B* they dip at an angle of about 10 degrees.

In *C* they dip at an angle of about 20 degrees.

In *D* they dip at an angle of about 30 degrees.

The upper line represents the etched surface of the section through the faces of the little cubes, some of which are inclined so as to form a series of little steps, just as in reality they are found after polishing and etching.

The thick dark line gives the direction in which fracture would be most readily effected from right to left.

The dotted lines at the upper part represent the angle at which the light must fall in order that it may be reflected vertically. The thin dots represent the incident rays or those which fall on to the surface, the thick dots the reflected rays. The angle made by the incident and reflected rays, divided by two, gives the angle of inclination which the upper faces of the molecular crystals bear with relation to the surface of the metal section.

The dark squares, some of which are large and others smaller, illustrate the manner in which the nitric acid selectively digs out or dissolves away perfectly square areas, leaving cavities of greater or less dimensions.

It is to be feared that the purely practical man will be ready to drop the subject at this point, as no doubt, from his view, there is nothing practical in what has just been stated; but let him wait a short time, and it will soon be apparent that without this introduction it would be impossible to explain satisfactorily the peculiar brittleness sometimes produced by annealing, and how it is

that so-called coarsely crystalline iron and steel are not invariably equally liable to break up.

It has been shown that large grains of pure iron can be readily split up in three directions. It follows that if a mass of iron in a plate or sheet consisted of one single grain built of molecular crystals in the same phase throughout, such a plate could be readily broken in two main directions, depending on the axial position of the crystals, one direction being always at right angles to the other.

It is equally clear that if the sheet or plate was built up of grains, either great or small, in which the axial positions of the constituent crystals were nearly but not quite in the same phase in all the separate grains, such a plate or sheet would be weakest and more readily broken in the same two directions. Probably there would be a difference between a small-grained plate and that built of coarser grains, but the difference would be only one of degree, not in direction; the tendency would be to break in rectangular lines in each, but one would more easily break than the other.

It will also be clear that if in a piece of iron a few grains near the surface are built up in the manner last described in the same phase, a properly directed force would tend to effect a cleavage at that point, and the cleavage once started would travel right through the piece.

On the other hand, if the orientation of adjoining crystalline grains is such that the cleavage planes are at a considerable angle to one another, even if the grains are comparatively large, such a structure would be less liable to break up than a finer grained but symmetrically oriented metal.

This comparison will be understood by the two diagrams on next page.

The crossed lines represent the cleavage planes in each grain. The coarse structure, Fig. 4, represents crystals heterogeneously arranged, whereas in the finer structure, Fig. 3, they are more symmetrical and the cleavages run in almost parallel lines. The latter type would be easily broken up, whereas the former would be strong and tough.

It is of course well known, all things remaining constant, that it is advisable to obtain structural and other steel as finely grained as possible. The above illustration is only introduced to show that crystalline arrangement may completely reverse this order, so that a coarse-grained metal may be stronger than one of finer grain.

The truth of the foregoing statement has been fully demonstrated in the research of the writer in his experiments at Middlesbrough and elsewhere.

It will be seen, then, that brittleness may be caused by the crystals arranging themselves in symmetrical fashion in contiguous grains.

Fortunately, as a rule, in iron and steel they do not grow or build themselves in such order, but are heterogeneously arranged. The illustration, No. 17, in the paper on crystalline iron, gives a type of such a structure. It nevertheless occasionally happens that under certain conditions it is otherwise, and the most excellently pure and soft material may be rendered quite brittle, and it is to the study of the conditions which favor such a state of things we must now turn our attention.

Granular Devolopment on Heating Iron to 600 to 750 degrees Centigrade.—It has been shown that on heating practically pure iron in the front part of a laboratory muffle furnace, where the temperature was between 600 and 750 degrees centigrade, the originally fine grains develop into grains of larger mass; or, to put it in another way, at the temperature of between 600 and 750 degrees centigrade the axes at many different angles of several contiguous grains alter their position until they become of the same angle in all, with a coincident disappearance of the granular junctions, the result being a larger grain containing the same mass as the sum of all the masses of the smaller grains added together. Technically expressed, the iron becomes more or less coarsely crystalline. These changes are not effected rapidly. Time is an important factor, and the conditions usually aimed at to soften and destroy the coarse structure in carbon steels, viz: long heating at a dull red heat, causes the development of large granules in practically carbonless iron, which may or may not

result in the material being brittle. If, for instance, the granules are composed of crystals, the cleavages of which generally lie at right angles to the length and cross-section of a bar of iron, such a bar will be easily broken. If, on the other hand, the cleavages are arranged heterogeneously, although the composition and size of the grains may be equal to the last described, a bar built up in such a fashion will stand comparatively severe punishment without breaking.

Whenever there are large granules there must be large cleavage planes or lines of weakness; and even although the axial position of the crystalline masses of which the grains are composed may be arranged in the best position to withstand resistance, it stands to reason that a larger number of smaller grains built up in the same way will be much stronger, and stand much greater punishment.

In the laboratory trials of the writer the coarse granular structure obtained by annealing pure iron at 700 degrees centigrade could not be broken by a sudden blow; and on examination microscopically, the etched grains, sometimes of large dimensions, were found, by the way they reflected light, to have their cleavages at other than right angles to the surface. These samples could be bent over upon themselves without fracture.

It was often found, however, that a coarse-grained bar, after bending to right angles, broke on straightening, whereas the same bar with fine grain could be straightened without breaking.

Although the trials in the laboratory did not give what may be called brittle crystalline iron, it is possible, if they had been repeated, or a sufficient number made, we might in time have obtained one which was so. Occasionally we have met with bars of practically pure Swedish material which were exceedingly brittle, and in which the cleavages were generally at right angles to the outer surfaces. Unfortunately, their previous history and the nature of the mechanical treatment they had been subjected to could not be ascertained, excepting that they had been annealed for a long period at a temperature under 700 degrees centigrade, and this was determined with certainty by microscopic examination.

Much work has been done with the endeavor to produce at will material with this brittle crystalline organization, but so far we have not been able invariably to do so. Mr. W. R. Lysaght, of Wolverhampton, has co-operated with the writer, and has done a very large amount of practical work at his suggestion, having annealed hundreds of samples, and rolled many samples of steel under different conditions.

One series of trials was most interesting and instructive.

Several tinplate bars were annealed in a close box for forty-eight hours at about 700 degrees centigrade. These when cold were cut in two, one-half of each being retained for examination and the others re-annealed for forty-eight hours. These when cold were again halved, and portions of each were annealed a third time. All the samples were examined mechanically and microscopically.

The size of the grain in the center of all the bars after repeated annealing was larger than in the same bars before annealing; but, after the first annealing, all the bars were enveloped with a coarsely granular layer. On polishing the surfaces, and then etching with nitric acid, granules measuring up to $\frac{1}{2}$ inch in diameter were revealed.

On attempting to bend them, some of them could be bent close, but others were easily fractured; but all of them after bending to 60 degrees on straightening again broke readily.

These samples, on heating to 900 degrees centigrade and allowing them to cool naturally, became exceedingly tough. They could be bent backwards and forwards without breaking. The coarse enveloping layer no longer existed. The simple heat treatment had converted the more or less brittle annealed material into tough and strong steel.

The change after the second annealing was very marked. The external layers of coarse granular steel were transformed into finer grained material, and now resembled the structure of the central portions, which remained moderately fine grained throughout after each annealing; but the remarkable feature was that the layer about $\frac{1}{8}$ inch below the now finer grained envelope was coarse grained, the grains being from 5 to 20

diameters greater than those both above and below it. The bars were not so easily broken as they were after the first annealing, as was naturally to be expected, judging from the difference in the character of the external envelopes.

The third annealing did not appear to produce much further change. It was noticed that the weakness of the bars after annealing once was confined to the grossly granular envelope, for, on removing it in a planing-machine, the interior portions were found to be strong and tough. The amount of carbon in these bars varied between 0.08 and 0.12 per cent. The external envelope after annealing contained only traces of carbon, clear enough proof that although the annealing was effected in closed iron boxes, which protected the iron bars from external oxidation, there must have been oxidizing gases present sufficient to oxidize some of the carbon, but which were insufficiently active to oxidize the iron itself to any perceptible degree. Mr. Lysaght has, however, quite recently repeated these experiments, and he has found that the brittle envelope is not always removed by re-annealing.

BRITTLENESS IN ANNEALED SHEETS.

I. *Inter-Crystalline Sheets.*—1. The examination of a large number of annealed sheets has revealed the fact that when their thickness is less than 22 B.W.G., brittleness is never developed, and that it is occasionally developed in sheets from 10 to 20 B.W.G.

2. That the preponderating quantity of thicker sheets, which are not readily broken when they leave the annealing pots, and which cannot be classed as brittle, after heating from 400 degrees to 500 degrees centigrade, and being subjected to jar or shock, which may or may not be sufficient to give a permanent set, almost invariably causes a development of a brittle character. The character of the weakness is sometimes inter-granular, but more frequently inter-crystalline. The lines of weakness in the former take no special direction, and the sheets break up exactly like cast iron. The weakest positions in the second class are invariably in certain fixed directions, viz: at angles approximating to 45 degrees to the direction the sheets were rolled, and

at right angles to the surface of the sheets. In other words, the weak lines correspond to the three directions of cleavage in a cube having four faces at 45 degress to the edges and two faces parallel to the surface of the sheets.

Such material can be bent and hammered close together when the bending is done longitudinally or at right angles to that direction, but it breaks off readily when bending is attempted at angles of 45 degrees to the direction in which the plates were rolled.

The peculiarity of breaking up in rectangular positions has long been noticed, but it does not appear that notice has before been taken of the invariably fixed relation which exists between the lines of fracture and the direction of rolling.

What is the cause of this peculiar relation?

It is evident that the rolling is the initial cause, but in no case whatever have the rolled sheets previous to annealing shown any tendency to break up in rectangular directions. The rolling of all these sheets is done when the steel is at a comparatively low temperature, about 600 degrees centigrade, and, as one would naturally expect, a fractured surface invariably presents a fibrous appearance, and the etched polished sections show the same appearance. This is clearly illustrated by the photographs, Fig. 6 (*a*) and (*b*), magnified 30 diameters, of the same sheet, before and after annealing. The rolled sheet *a* is fibrous, the annealed sheet *b*, coarsely granular. The first was not brittle, the second, on very severe punishment, broke with rectangular fracture.

Fig. 8 is a photograph, about half natural size, of the test-pieces which had been subjected to a severe stamping test: *a* rolled sheet; *b* after annealing; and *c* after heating to 900 degrees centigrade.

We are led to conclude that, just as light impresses a latent image on a bromide photographic plate which cannot be seen, but is developed and made manifest by the action of certain chemical agencies, so the rolling appears to impress a latent disposition in the steel to crystallize in certain fixed positions, and annealing develops it afterwards.

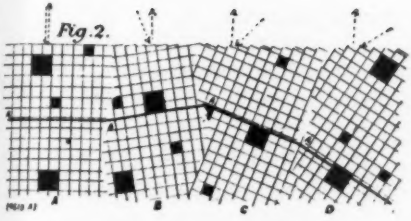


Fig.2.
A
B
C
D

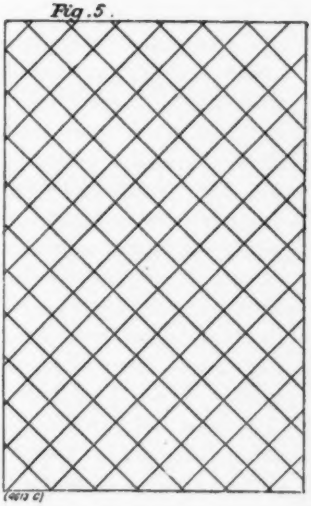


Fig.5.

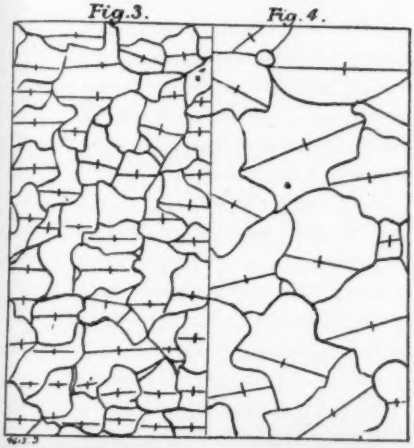
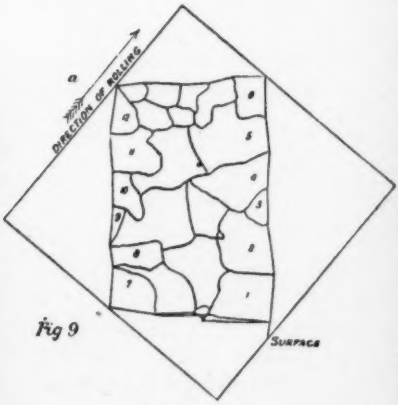
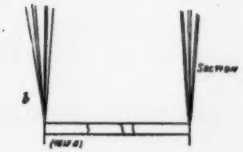


Fig.3.
Fig.4.


a
DIRECTION OF ROLLING
Fig 9
SURFACE

A. FIG. 6. B.


SECTION
b

It is difficult to determine with certainty the exact nature of the change which rolling effects, but, from the general microscopic appearance of etched specimens and fractured surfaces, it would appear that there is a tendency for iron to etch out into thin plates, and when such etched specimens are distorted or are pulled out, for these plates to slide over each other. The rolling of the sheets is at such a temperature that the rolled out and flattened granules have little opportunity to reorganize themselves into equi-axed polygonal masses before they become cold; and it appears probable that the rolling causes the crystalline plates to slide one over the other, with their angular points generally in the direction in which the sheets are elongated and at right angles to such direction, and that the general position of all the crystals are shown in Fig. 5. When such a sheet is annealed, the crystalline forces begin to act, and at multitudes of centers a systematic marshalling of the minute crystals begins, and the resulting large crystalline masses or grains then have their crystalline axes and cleavages approximating to the same direction of the smaller and more minute grains in the rolled plate.

One very fine example of very gross granulation was met with in an annealed plate. It had been rolled to 16 B.W.G., and afterwards annealed for forty-eight hours.

It had the following composition:

	Per cent.
Carbon,	0.035
Manganese,	0.331
Silicon,	trace.
Sulphur,	0.019
Phosphorus,	0.057

It is remarkable for its low sulphur and carbon content. Probably the carbon in the rolled sheet was not less than 0.09 per cent., the difference, 0.055 per cent., having been oxidized in the annealing. Fig. 7 is reproduced from a photograph, natural size, of this sheet, after etching with nitric acid, 1 to 10 water, for ten minutes.

On looking at the original illuminated with vertical light,

about one-third of the granules appeared bright, and on moving the plate to angles of 10 degrees in different directions, nearly all the grains became successively bright—a proof that the molecular crystal faces were nearly coincident with the flat surface of the plate. The other crystal faces generally lie at angles of 45 degrees to the direction in which the sheet was rolled, varying from about 40 degrees to 50 degrees. These facts, microscopically determined, were more fully proved by fracturing the specimen and measuring the angles of the cleavage faces. The diagram, Fig. 9 (*a*) and (*b*) illustrates this. It represents another portion of the same sheet as is represented in Fig. 7. The piece in the center of the square was separated by properly directed blows with a hammer. Fractures followed the lines of weakness, and the rough-shaped rectangular piece illustrated was obtained. The vertical cleavages were clean and true, and passed practically from front to back of the plate. It was, therefore, easy to measure the angle of the cleavage face of each fractured crystal grain. The lower sketch represents a section through (*a*), and the lines drawn upwards at the ends represent the continuation of the crystal faces of the several grains at each side of the specimen. It will be noticed that the variation is slight, and they approximate closely to right angles to the surface.

There was one small grain at the center of the lower portion with crystal faces at 45 degrees to the surface, and, just as might have been expected, cleavage from opposite sides stopped on each side of this grain, and it was only after bending this grain backwards and forwards that the two pieces could be separated.

Strips cut from this sheet could be pulled out and elongated nearly 30 per cent. before breaking, and stood much punishment supplied in all directions other than at the cleavage lines of weakness.

By heating to 900 degrees centigrade for one minute, all the peculiarities vanished, and it became fine grained and tough in every direction.

II. *Inter-granular Weakness.*—There has not been sufficient evidence to enable us to form dogmatic conclusions as to the cause of inter-granular weakness, but in the two or three cases

examined, the phosphorus was found to be excessive. One very brittle piece contained:

	Per cent.
Carbon,	0.040
Manganese,	0.431
Silicon,	trace.
Sulphur,	0.063
Phosphorus,	0.263

Re-annealing for forty-eight hours did not restore its good qualities, but it changed its character, the line of fracture traversing both through the grains and at their junctions.

How to Prevent Brittleness.—The whole study and work on the subject of crystalline iron was made in order that we might ascertain the conditions leading to the development of brittleness, and so find out what to avoid, and also to ascertain if anything could be done afterwards by any special treatment to convert brittle material into steel, tough and reliable. In the more recent investigations of brittle sheets the following facts have been noted:

1. Occasionally one end of a sheet may be tough and good, and a portion of the other more or less brittle. In one case examined there was found to be no difference in the composition between the two varieties. Presumably we must conclude that the conditions of annealing were not absolutely identical. It is difficult to see where or how such a difference could occur, unless we assume that the thermal conditions were unlike and responsible.

2. That sometimes one side of a sheet is brittle, the other being quite tough. Fig. 6 (*b*) is an example of this. The photograph was taken along a line 45 degrees to the direction of rolling, and the specimen was illuminated with oblique light. It will be noticed that the inside grains are generally darker than those outside. This indicates cleavage faces nearly in one plane in the grains on the brittle side. This side was brittle, the other was tough.

3. Sometimes the outside is brittle, and the inside tough.

4. There are cases in which the outside envelope is tough, and the inside quite brittle.

These cases where, in the small width of about $\frac{1}{16}$ inch, there existed both brittle and tough material, must put an end to the supposition that difference in chemical composition is in any way an important factor.

Heating the rolled sheets up to 900 degrees centigrade followed by slow cooling would undoubtedly give tough material; but 900 degrees centigrade is so high a temperature, the annealing boxes would suffer rapid destruction if heating to so high a degree was adopted.

It will no doubt occur to many that if rolling the sheets in one direction only is the initial cause of rectangular weakness, rolling at various angles, so that one latent impression may be neutralized by a second, that brittleness would be in that way avoided. It would, of course, be impracticable to roll in such a way to any extent, at least without making a circular sheet, and with our present plant it would be impossible. It appears probable, however, that if the last two or three passes were made alternately at angles of say 15 degrees in the longitudinal direction, first on one side and then on the other, the tendency to develop brittleness would be greatly reduced, if not eliminated. Such treatment would undoubtedly result in sheets of irregular shape and a consequent greater production of scrap; it is not likely, therefore, that advantage will be taken of it.

It has already been mentioned that sheets of 22 and higher gauges never develop rectangular brittleness, and that it is only in the thicker sheets it is obtained.

What is the cause of this difference? Does the rolling continued beyond a certain point destroy the latent arrangement set up before that point is reached?

This question we cannot answer with our present knowledge.

The whole problem is surrounded with many practical difficulties, and it is certain that until we have means at hand of practically controlling and determining the temperature for forty-eight and more hours of the annealing pots, it will be useless to continue the study. The fact that contiguous parts of the same sheets differ materially in brittleness, the composition being the same in each part, and that different parts of the pots vary in

temperature, would lead us to believe that proper temperature is the all-important factor.

The one important point which we may consider to be established is, that phosphorus should not be allowed to exceed about 0.08 per cent.

A sample of steel which was exceedingly brittle in rectangular lines, and which, although it was annealed repeatedly, still maintained its brittle cleavage character, contained:

	Per cent.
Carbon,	0.11
Manganese,	0.345
Silicon,	trace.
Sulphur,	0.090
Phoshorus,	0.128

In conclusion, it must be admitted that the study of this most important subject is not only of the highest scientific interest, but of the greatest practical importance. It would be well if more attention was paid to it, and it is hoped that the results recorded in this note will stimulate others to follow up the investigation.

The writer acknowledges with gratitude the valuable co-operation of Mr. W. B. Lysaght.

TRIAL OF THE STEEL CARGO STEAMSHIP *WINIFRED.*

By Assistant Engineer A. D. Haughton, U. S. Navy.

The *Winifred* is the pioneer American single-screw cargo steamship, built to compete with the English *Tramp*. She was built by the Bath Iron Works, of Bath, Maine, for Miller, Bull & Knowlton, managing owners, of New York, N. Y., from the builders' designs. The contract was signed December 12, 1897. The keel was laid January 31, 1898. She was launched July 8, 1898. The speed is 10 knots per hour with the vessel loaded to a mean draught of 18 feet 9 inches, at which draught she will carry about 3,600 tons dead weight. The ship goes immediately on the New York and Porto Rico Steamship route. Her smokestack colors are yellow, white, yellow. Her house flag is red and white stripes with blue stars.

HULL.

The hull is constructed of mild steel of domestic manufacture, with frames spaced two feet apart throughout. She is in every respect an American vessel, and her scantlings conform to the requirements of all the classification societies, such as American Shipwrites and Lloyds.

The ship is divided into seven water-tight compartments. A double bottom extends the whole length of the vessel; it is four feet deep and is divided into eight water-tight tanks; the two under the engine and boiler rooms are used for fresh water, the remainder are for water ballast.

Coal Bunkers.—The coal bunkers are located on each side of the engine and boiler rooms, and between the back end of the boilers and the forward hold bulkhead. The coal capacity of bunkers is 450 tons, based on 43 cubic feet to the ton. The two

bunkers on the sides of the engine room are reserve bunkers available for cargo.

Hold.—The hold forward is divided into two parts by a water-tight bulkhead, the same is also true of the after hold. Each of the four holds for cargo have a large hatch 14 × 26 feet, with a double winch for handling the cargo. The engine and boiler rooms are in one water-tight compartment with a dust-proof partition between them.

Cabin Space.—The vessel has a poop, bridge and forecastle. The space in the poop is divided into nine state rooms, two bath rooms, saloon and pantry for passengers. The space in the bridge house is divided into nine state rooms, saloon, galley, bath room, pantry and two mess rooms; these are for the use of the officers. There is also a cabin and state room just abaft the pilot house for the use of the captain. The forecastle contains eighteen berths, water closet and wash room for the crew, also a vegetable room, lamp room, ice room and a carpenter room.

Drainage.—For draining the compartments, pipes are run from each to the engine room, where they attach to manifolds and through them to the steam pumps. The double-bottom tanks are emptied in a similar manner and are filled by gravity. Each compartment, except that of the engine and boiler room, has a hand pump connected for use in emergencies.

The boats carried are as follows: two 22-foot double-ended life boats; one 20-foot double-ended life boat; one 18-foot cutter.

All the machinery is well below deck. The galley is 6 × 14 feet and is fitted with a large range. There is a small compartment forward used for a chain locker, and one aft used for a trimming tank. The ship carries three stockless bower anchors, each 4,760 pounds weight; one stream, of 1,200 pounds weight; two kedges; 240 fathoms of $1\frac{7}{8}$-inch and 75 fathoms of $1\frac{1}{8}$-inch chain. The ship requires a crew of twenty-eight men—fourteen for the engine room and fourteen for the deck.

Length, load water line, feet	290
Length over all, feet and inches	304–3
Moulded beam, feet	42
Moulded depth, feet and inches	25–8

Depth of hold, feet and inches	23–8
Height of bridge deck above main deck, feet and inches	7–3
Loaded draught, feet and inches	18–9
Freeboard when loaded, feet and inches	6–1½
Capacity of holds, exclusive of coal and stores, cubic feet	175,500
Capacity, dead weight, tons	3,600
Capacity, tanks for fresh water in double bottom, tons	175
Capacity, tanks for water ballast in double bottom, tons	625
Capacity, tanks for fresh water, domestic use, tons	13
Probable load draught with Lloyds' freeboard, feet	20

MAIN ENGINES.

There is one vertical, inverted, direct-acting, triple-expansion engine placed in a water-tight compartment, the high pressure cylinder forward.

The cylinders are supported by a common box frame, with condenser combined on the back side, and by hollow cast-iron cylindrical columns on the corners of the front side, and with an inverted Y frame in the center between the hollow columns. The cylinders are not jacketed; the H.P. cylinder only is fitted with working liners. There are no starting valves on the cylinders, but provision is made for admitting live steam to the receivers for starting. The relief valves for the cylinders are placed on the ports on each end of each cylinder. The H.P. valves are 2 inches and set at 170 pounds; the I.P., 2½ inches, set at 80 pounds; the L.P., 3 inches, set at 30 pounds. The main valves for the H.P. and I.P. are single-ported piston type, one for each cylinder. The L.P. cylinder has a double-ported slide valve provided with a balance piston 7½ inches diameter. The valve gear is of the Stephenson type with double bar links. There are no independent cut-off valves, but provision is made to cut off for each cylinder from .5 to .7 of the stroke, by means of a block to which the suspension links are attached, which block can be moved by hand screws in the end of the arm on the reversing shaft.

The main pistons are cast iron, straight on the bottom, but coned on the top; each are fitted with three rings of packing, two outer rings and one inner ring, the outer rings are 1 inch thick by 1¾ inches wide, the inner ring ½ inch thick by 3½ inches

wide. The piston and connecting rods are of forged iron. The crossheads are of forged iron, and each has a bronze slipper gib on sliding faces. The crosshead guides are of cast iron, bolted to the frame above and on inside of the condenser. The eccentrics are made of cast iron and are securely keyed to the shaft. The eccentric straps are of cast iron. The rods are of wrought iron, also the eccentric crossheads and link blocks. The bed plate is made in two sections, of cast iron.

The reversing gear consists of a steam cylinder seven inches diameter. The rod is secured to a crosshead, which connects with the arm on the reversing shaft. The valve is so adjusted that the piston follows the motion of the hand lever and is held when stopped by direct steam pressure, no hydraulic controlling cylinder being used.

The engines are turned over with a hand turning gear, consisting of a worm and pinion. To the worm a hand wheel is attached. The worm is attached to sliding bearings so as to be held in or out of gear by means of a catch.

The engine is fitted with a disc stop valve, six inches diameter, having a screw stem, and a double poppet valve, seven inches diameter. The main steam pipes are of copper.

Cylinders, number of	3
Cylinder, H.P., diameter, inches	20½
Cylinder, I.P., diameter, inches	34
Cylinder, L.P., diameter, inches	55
Stroke of pistons, inches	36
Valves, H.P., diameter, inches	14
Valves, I.P., diameter, inches	16
Valves, L.P., width, feet and inches....4–4; length, feet and inches,	3–0
Balance piston, L.P., diameter, inches	7½
Valve stems, H.P., inches	2
Valve stems, I.P., inches	2
Valve stems, L.P., inches	2
Main steam pipe (7 inches diameter), area cross section, inches	38.48
Exhaust pipe, H.P. (8½ inches diameter), area cross section, inches	56.75
Exhaust pipe, I.P. (9½ inches diameter), area cross section, inches	70.88
Exhaust pipe, L.P. (14 inches diameter), area cross section, inches	153.9
Volume swept by H.P. piston (mean), per stroke, cubic feet	6.88
Volume swept by I.P. piston (mean), per stroke, cubic feet	18.91
Volume swept by L.P. piston (mean), per stroke, cubic feet	49.50

Net area of I.P. to H.P. piston	2.75
Net area of L.P. to I.P. piston	2.62
Net area of L.P. to H.P. piston	7.19
Clearance of H.P. cylinder, per cent.....top, 14.35; bottom,	16.65
Clearance of I.P. cylinder, per cent.....top, 11.14; bottom,	12.92
Clearance of L.P. cylinder, per cent.....top, 14.45; bottom,	15.65
Piston rods, diameter, inches	$4\frac{1}{2}$
Piston rods, length from piston to crosshead, feet and inches	$4-8\frac{3}{4}$
Connecting rods, length from center to center, feet and inches	$6-1\frac{7}{8}$
Connecting rods, diameter of upper end, inches	$4\frac{1}{2}$
Connecting rods, diameter of lower end, inches	$5\frac{1}{2}$
Connecting rods, crank-pin bolts (2), diameter, inches	$2\frac{1}{2}$
Connecting rods, crosshead bolts (4), diameter, inches	$1\frac{3}{4}$
Crosshead surface, 20 by $11\frac{1}{2}$, square inches	230
Crosshead pins, diameter, inches	5
Crosshead pins, length, inches	5
Reversing gear, steam cylinder, diameter, inches	7

Shafting and Bearings.—The crank, line, thrust and propeller shafting is solid, made of forged iron. The crank shaft is a built-up shaft in one piece or section, the cranks and shaft are of forged iron and the crank pins are of forged steel. The cranks are placed at angles of 120 degrees, and for the head motion follow in the order of H.P., I.P., L.P. There are three sections of line shafting supported on four bearings. The propeller shaft is fitted with a composition casing from inboard the stern tube to the propeller. The shaft coupling bolts are finished to fit the holes snugly. They are put in from the after side of the coupling and set up on the forward side with a wrought-iron nut and split pin.

Each thrust bearing is of cast iron, of the horse-shoe pattern. The end and side walls of the pedestal form an oil way, inside of which, both forward and aft the horse shoes, is a composition bearing lined with white metal for taking the weight of the shaft. The cap of this bearing is of cast iron lined with white metal. There is an oil cup on the top of each horse shoe, from which there is an oil hole to each collar, the white metal being channeled for the distribution of the oil. At each end of the bearing there is a divided stuffing box and gland to prevent the escape of oil.

Crank shafts, diameter, inches	10
Crank shafts, coupling discs, diameter, inches	19
Crank shafts, coupling discs, thickness, inches	3
Crank shafts, coupling discs, number bolts in one flange, tapering	7
Crank shafts, coupling discs, diameter bolts large end, inches	2⅜
Crank shafts, coupling discs, diameter bolts small end, inches	2
Crank shafts, journals, diameter, inches	9½
Crank shafts, journals, length, inches	15
Crank shafts, length of crank shaft section, feet and inches	15–10⅝
Crank pins, diameter, inches	10
Crank pins, length, inches	15⅜
Crank webs, width, inches	14
Crank webs, thickness, inches	8¼
Thrust shaft, diameter, inches	9½
Thrust shaft, coupling discs, diameter, inches	19
Thrust shaft, number of collars	8
Thrust shaft collars, diameter, inches	17¼
Thrust shaft collars, thickness, inches	2½
Thrust shaft collars, distance between, inches	5
Thrust shaft collars, surface, square inches	1,302.64
Thrust shaft, length of shaft, feet and inches	26–11
Line shaft, diameter, inches	9½
Line shaft, diameter of coupling discs, inches	19
Line shaft, length, feet and inches	68– 1½
Propeller shaft, diameter, inches	10 9/16
Propeller shaft, diameter coupling disc, inches	19
Propeller shaft, length, feet and inches	27– 0

Condenser.—The condenser shell is of cast iron, made a part of the engine frame. The circulating water passes into the bottom of condenser through the tubes, and out from the top. Baffle plates are fitted to direct the steam over the tubes, and plates are provided for supporting the tubes and also to act as baffle plates.

Width of shell, feet and inches	2– 2¾
Height of shell, feet and inches	4–10
Length over heads, feet and inches	12–11
Tubes, number of in condenser	588
Tubes, cooling surface, square feet	1,427
Tubes, diameter (outside), inch	¾
Tubes, length between heads, feet and inches	12–0
Tubes, thickness, No. 18, B.W.G., inches	.049
Ratio of cooling surface to heating surface	1 to 2.85

Main Air Pump.—The air pump is driven from the engine crosshead and is a single-acting pump. The valves are made of vulcanized rubber.

Diameter of cylinder, inches	21
Length of stroke, inches	14
Diameter of pump rod, inches	2½
Diameter of pump valves, inches	5½
Ratio of volume swept by L.P. piston to that of air-pump piston	35.36

Circulating Pump.—The condenser has a direct-acting, independent, duplex Worthington pump, which is arranged to draw water from the sea, bilge and main drain pipe, and to discharge either direct overboard or to the condenser.

Diameter of steam cylinders, inches	7½
Diameter of water cylinders, inches	8½
Length of stroke, inches	10
Capacity in gallons per minute	500

Screw Propeller.—The propeller is made of cast iron, with four solid blades. It is a true screw, and has a pitch of 11 feet 9 inches.

Number of blades	4
Diameter, feet and inches	13- 0
Diameter of hub, feet and inches	1-10½
Length of hub, feet and inches	1-11½
Pitch, feet and inches	11- 9
Greatest width of blade (4 feet from axis), feet and inches	2- 9
Projected area, feet	43.50
Disc area, feet	132.73
Pitch divided by the diameter	.915
Projected area divided by the disc area	.342
Helicoidal area of screw, square feet	50.52
Helicoidal area divided by the disc area	.38
Center above lowest point of keel, feet and inches	7- 4

BOILERS.

The ship is provided with two boilers of the Scotch, fire-tube type, 12 feet 5 inches diameter, 12 feet 3 inches long. Each boiler has three corrugated furnaces. The shell of each boiler is in two courses of three sheets to the course. The longitudinal joints are treble riveted with double butt straps. The cir-

cumferential joints are lapped and double riveted. The joints in the furnaces and combustion chambers are single riveted. The furnaces are fitted with double bar grates spaced $\frac{5}{8}$ of an inch. Each boiler has one double 4-inch safety valve in one case. The tubes are all of steel. The boilers are placed side by side, using one smoke stack made of steel. The working steam pressure is 165 pounds.

DATA FOR ONE BOILER.

Length, feet and inches	12–3
Diameter, feet and inches	12–5
Thickness of shell, inches	$1\frac{1}{16}$
Thickness of heads, at top, inch	$\frac{7}{8}$
Thickness of heads, at bottom, inch	$\frac{5}{8}$
Thickness of tube sheets, inch	$\frac{11}{16}$
Thickness of furnaces, inch	$\frac{17}{32}$
Thickness of combustion chamber, inch	$\frac{9}{16}$
Furnaces, greatest internal diameter, feet and inches	3–9
Furnaces, least internal diameter, feet and inches	3–6
Furnaces, length of grate, feet and inches	6–6
Grates, number in each boiler	96
Tubes, outside diameter, inches (No. 12, B.W.G.)	$2\frac{1}{2}$
Tubes, length between tube sheets, feet and inches	8–3
Tubes, number in each boiler (No. 12, B.W.G.)	261
Tubes, number in each boiler (No. 6, B.W.G.)	52
Tubes, spaced vertically, inches	$3\frac{5}{8}$
Tubes, spaced horizontally, inches	$3\frac{5}{8}$
Diameter of rivets in shell, inches	$1\frac{1}{8}$
Diameter of screw stays, inches	$1\frac{1}{2}$
Diameter of pitch of screw stays, inches	$7\frac{1}{2}$
Diameter of through upper braces (18), inches	$2\frac{5}{8}$
Diameter of through lower braces (10), inches	$2\frac{1}{2}$
Heating surface, tubes, square feet	1,755
Heating surface, furnaces, square feet	148
Heating surface, combustion chamber, square feet	130
Heating surface, total, square feet	2,033
Grate surface, square feet	70
Area through tubes, square feet	$8\frac{5}{8}$
Area over bridge wall, square feet	$9\frac{1}{4}$
Volume of furnaces and combustion chamber above grates	312
Steam room, water four inches above highest heat surface	300
Water surface, square feet	127
Diameter of safety valves (2), inches	4
Diameter of boiler stop valve, inches	6
Diameter of auxiliary stop valve, inches	4

Totals for the two boilers:	
Heating surface, square feet	4,066
Grate surface, square feet	140
Area through tubes, square feet	17½
Area over bridge walls, square feet	18½
Volume of furnaces and combustion chambers above grates, cubic feet	624
Steam room, cubic feet	600
Area of water surface, square feet	254
Ratios:	
Heating surface to grate surface	29
Volume of furnaces and combustion chamber to grate surface	4.47
Steam room to grate surface	4.28
Water surface to grate surface	1.81

Auxiliary Boiler.—The ship is provided with one auxiliary boiler, which is located in boiler room, the smoke pipe connecting to the main boiler's pipe. The boiler is a Scotch dry-combustion-chamber type with one furnace. It is 6 feet 7½ inches diameter, 7 feet $9\frac{9}{16}$ inches long. The shell is made in one sheet, lap joint and double stagger riveted. The grates are of the same pattern as the main boilers. The safety valve is 3 inches diameter, set at 120 pounds pressure per square inch.

Length, feet and inches	7–$9\frac{9}{16}$
Diameter, feet and inches	6–7½
Thickness of shell, inch	⅝
Thickness of heads, inch	½
Thickness of furnace, inch	⅝
Furnace, greatest internal diameter, feet and inches	3–6
Furnace, least internal diameter, feet and inches	3–3
Furnace, length of grate, feet and inches	5–7
Furnace, number of grates	32
Tubes, outside diameter (No. 12, B.W.G.), inches	2½
Tubes, length between heads, feet and inches	7–7½
Tubes, number of	102
Tubes, spaced vertically, inches	3⅜
Tubes, spaced horizontally, inches	3⅜
Diameter of rivets in shell, inches	⅞
Diameter of through upper braces (10), inches	1½
Diameter of through lower braces (2), inches	1¼
Heating surface, square feet	538
Grate surface, square feet	17.6
Area through tubes, square feet	3
Area above bridge wall, square feet	3
Volume of furnace and combustion chamber above grates, cubic feet	50

Steam room, water 4 inches above highest heating surface, cubic feet	58.5
Water surface, square feet	45
Diameter of safety valve, inches	3
Diameter of stop valve, inches	4
Ratio heating surface to grate surface	30
Ratio steam room to grate surface	3.32
Ratio water surface to grate surface	2.56

FEED PUMPS.

There are two main and one auxiliary feed pumps. The two main feed pumps are connected direct to, and are driven by, the crosshead of the main engine by means of a rocking beam. The pumps are single-acting plunger type, with two composition, straight-lift valves to each pump.

Diameter of plunger, inches	3¾
Diameter of valves, inches	4
Diameter of suction and discharge pipes, inches	2½

The auxiliary pump for feeding the boilers is a direct-acting, duplex, Blake's horizontal, double-acting pump, located on starboard side of engine room.

Diameter of steam cylinder, inches	7½
Diameter of water cylinder, inches	4½
Length of stroke, inches	10
Capacity in gallons per minute	130

The main feed pump takes water from the filter box and discharges into the boilers. The auxiliary feed pump takes water from the filter box, sea, water tanks, and from the blow-offs of the boilers, and discharges into the boilers.

FIRE PUMP.

The fire pump is located on starboard side of engine room just under the main deck. It is a duplex, double-acting, horizontal Blake pump, and draws water from the sea, bilge, tanks and boilers, and discharges into the fire main, overboard, ash ejector, boilers and condenser.

Diameter of steam cylinder, inches	10
Diameter of water cylinder, inches	6
Length of stroke, inches	10
Capacity of pump in gallons per minute	275

BALLAST PUMP.

The ballast pump is located in the engine room just forward of the auxiliary feed pump. It is a single-cylinder, double-acting Blake pump, and takes water from the ballast tanks, sea and the bilge, and discharges overboard, condenser and into the ballast tank.

Diameter of steam cylinder, inches	7½
Diameter of water cylinder, inches	8
Length of stroke, inches	8
Capacity in gallons per minute	250

BILGE PUMPS.

There are two single-acting plunger pumps, connected up with the main feed pumps and driven by the same rocking beam. They draw from the bilge and discharge overboard or into the condenser.

Diameter of plunger, inches	4
Diameter of valves, inches	3
Diameter of suction and discharge pipes, inches	3

The valves are composition swing-jointed, and the side of pump arranged with blank flanges so the valves are accessible.

INJECTOR.

There is a 2-inch Hancock injector, located in the engine room, arranged to draw from the tanks, sea or bilge, and discharge into the boilers or the engine room for cleaning.

ASH EJECTOR.

There is a Horace See hydraulic ash ejector in the fire room. The ejector is made of 6-inch cast-iron pipe, leading up at an angle of about 45 degrees under the main deck, then with an easy bend discharging overboard. The ash hopper is located at the bottom end of the 6-inch pipe, at which point it makes a sharp bend upwards and in appearance resembles a pipe bowl and stem. A nozzle, which is connected to the fire pump, projects through the side of the bowl and into the stem of the ejector.

FILTER BOX.

A filter box is located near the main feed pumps, into which the air pump discharges. The box is divided into ten compartments five inches wide; the first partition extends from the top of the box to within three inches of the bottom, the second is left down three inches from the top and extends to the bottom, continuing thus throughout the whole box. The compartments are filled with the filtering materials. The water is discharged into the first compartment and goes through the space at the bottom of the partition into and up through the second compartment, over the second partition and down through the third compartment, continuing thus to the last compartment, to which the feed pump suction is attached.

VENTILATING FAN.

There is a ventilating fan located in the boiler room, used for ventilating the engine and boiler rooms.

Diameter of steam cylinder, inches	3½
Stroke, inches	5½
Diameter of fan, inches	54
Width of fan, inches	19

ENGINE-ROOM TELEGRAPH.

There is a Cory mechanical telegraph in the engine room connected to transmitters in the pilot house. Mechanical telltales are fitted so the engineer can answer the signals. There is also an independent bell, with pulls in the pilot house, for use in case of disarrangement with the telegraph. Voice tubes are also connected between the engine room and the pilot house.

STEERING ENGINE.

On the upper grating in the engine room there is a Williamson Bros.' steam steering engine; cylinders, 6 inches diameter, 7 inches stroke. The engine is connected to a horizontal shaft running athwartships, on which a worm-and-pinion gear connects to a drum, over which the cables work attached to the rudder.

STEAM WINDLASS.

On the forecastle deck is a Hyde Windlass Co. steam windlass. The engine has double cylinders, 6 inches diameter, 8 inches stroke. The windlass is fitted with two drums to take the hawsers.

WINCHES.

There are four Williamson Bros.' double-cylinder winches located as follows: one just abaft the forward hold, one just forward the second hold forward, one just forward the after hold, one just abaft the second hold aft. Each winch has a double lift.

STEAM TRIALS.

The steam trials took place off the coast of Maine on Monday, September 26, 1898. The trial consisted of two runs over the measured mile. The maximum speed, after allowing for tidal influences, was 11¼ knots per hour. The weather was fine, with a light wind from the southerly. The ventilating fan was not used and the boilers were run with natural draft. They steamed easily and showed no signs of priming. The engines worked very regularly and with but slight vibration. The ship was run for five hours at about a ten-knot speed. No water was used on the bearings, and after the run the engines were found in good condition.

DATA OF TRIAL.

Draught, forward, feet and inches	6–5
Draught, aft, feet and inches	12–3
Draught, average, feet and inches	9–4
Maximum speed, knots	11.25
Slip of screw (19 inches of blade was out of water), per cent	12.77
Revolutions of engines per minute, mean	105.5
Piston speed, mean per minute, feet	633
Steam pressure at boilers, per gage	150
Steam pressure at engine, per gage	148
Steam pressure at first receiver, absolute	55
Steam pressure at second receiver, absolute	18.5
Vacuum in condenser, inches	22
Steam cut off in fraction of stroke, all cylinders	.6
Double strokes of circulating pump per minute	40
Temperature, engine room (no ventilating fan used), degrees Fahrenheit	78

Temperature, fire room, degrees Fahrenheit	80
Temperature, outside atmosphere, degrees Fahrenheit	60
Temperature, injection water, degrees Fahrenheit	56
Temperature, discharge water, degrees Fahrenheit	90
Temperature, hot-well water, degrees Fahrenheit	130
Mean pressure in H.P. cylinders, pounds per square inch	77.2
Mean pressure in I.P. cylinders, pounds per square inch	21.6
Mean pressure in L.P. cylinders, pounds per square inch	6.5
I.H.P., H.P. cylinder	488.04
I.H.P., I.P. cylinder	376.176
I.H.P., L.P. cylinder	296.224
I.H.P., total	1,160.44
Indicated thrust, pounds	30,088.35
Indicated thrust per square foot developed area, propeller	595.57
Cubic feet swept per minute by L.P. piston, per I.H.P	9.
Ratio of volume swept by L.P. piston to air pump, per minute	35.36
Square feet of cooling surface per I.H.P	1.23
Square feet of heating surface per I.H.P	3.50
I.H.P. per square foot of grate surface	8.28
I.H.P. per square foot of heating surface	.285

WATER-TUBE BOILERS A NECESSITY.—A WAR LESSON.

By Passed Assistant Engineer J. K. Robison, U. S. Navy.

The United States Navy has passed through a glorious war, glorious because victorious, but most glorious because every man in the Navy has done his duty. This is true from those in highest command to those of the lowest ranks. There have been many cases of men that have done more than their duty, but no single case is recorded of a failure to perform his duty on the part of anyone in the Navy.

It was a grand thing to gain the battles of Manila Bay and Santiago, and it may seem no very great thing to be able to say that every man has done his duty. But if every man did his duty at all times, would there be any further need of preachers in our pulpits? Would Navies exist?

This war has been short, yet full of naval incident and strategy. It was the first war between navies that depended entirely upon modern steam machinery for their motive power, if one may except the comparatively unimportant war between China and Japan. Many naval lessons are to be learned from this war. These will concern the use and equipment of gun and torpedo, the value of armor, as well as the determination of the types of vessels required to make up a most efficient navy, and the general design of our war ships. Passing by these questions, as belonging to another sphere, I desire to call attention to one of the great lessons that engineers have to learn from this war, a lesson that concerns the whole Navy, but more particularly engineers.

To engineers it is a matter of no small amount of pride that the machinery of the vessels of our Navy has been satisfactory under the trying conditions of war. Naturally many obstacles have had to be surmounted, many mishaps have occurred and

makeshifts used; but there have been no disasters, and the use of makeshifts has been the mark of the resourceful engineer. Speaking generally, the performance of the machinery has been thoroughly satisfactory.

Most of the conditions that obtained during the war had been foreseen, and ships had been designed taking these conditions into account. Certain of the war conditions, however, developed an importance that makes them worthy of note and consideration.

There is much credit to be given to the administration of the Navy. The complaints concerning a failure to receive supplies have been very few, more especially towards the close of the war, after a boat had been fitted out especially to provide engineers' supplies. This great question was most ably handled under the most difficult circumstances. The stores required were of a very varied character, and the fleet was at all times quite distant from any naval base of importance. It became necessary to fit out a fleet of colliers to supply that prime essential of modern naval warfare, coal, together with oil and other stores. Water boats, supply ships and a most valuable repair ship were fitted out and used.

The importance of coal had been fully foreseen, and as rapidly as possible its supply was provided for by the colliers. None of these ships were ready at the beginning of the war, but before it closed these vessels had been provided, fitted out, and had done much valuable service. The same applies to the repair ship. The long and varied list of work done on nearly every vessel of the fleet, at one time or another, by the *Vulcan*, shows how wise was the provision for a vessel of this type. The importance of general supply ships, water boats and hospital ships was soon manifest, and provision for them made early in the war.

One thing in the matter of engineers' supplies was very prominently developed—the value of *uniformity* in the stores and spare parts required by different ships. It was impossible to predetermine exactly what stores would be required by any particular ship. It would have been a great advantage if such things as grate bars and boiler tubes could have been carried on the supply ships that would have fitted any ship of the fleet. Instead

of this, it was necessary to carry such stores of separate fixed patterns for every ship requiring them. These patterns were not always at hand, being scattered throughout the different naval stations and shipyards. The value of uniformity in design was well developed.

The great increase in the materiel of the Navy, that began even before the war was declared, together with the even greater increase in the personnel that accompanied this increase in the materiel, brought into play conditions that could not be entirely provided for. The doubling of the personnel of the Navy during the war meant that on board all of our ships came new men, men unused to naval life and discipline, and, in many cases, unused even to the sea. This made an engineer's force that was heterogeneous. The officers came from the regular officers of the Navy and from the colleges and technological schools of the country, as well as from the merchant marine. The enlisted men came from Texas and from Illinois, as well as from those who had been accustomed to a sea-faring life.

It required time to accustom these men to the duties that they were called upon to perform. This *time* was the one thing that could not be given them. The firemen and coal passers needed time perhaps less than did the petty or commissioned officers. To properly perform their duties water tenders must be thoroughly familiar with the ship on which they serve. Oilers must know their engines before being able to do their best work. Machinists had to learn what to watch and how to get around the ship to make repairs. Many machinists had even to learn how to stand an engine-room watch. A man cannot necessarily run a marine engine well because he is a good lathe hand and makes good tools, while it was from this class of men that came a large part of the machinists enlisted during the war. The officers were, in general, well educated men, most of whom had had previous sea service in engine rooms. But they had to meet conditions that were entirely new to many of them. In all cases, both for officers and men, it took time to become efficient in the true sense of the word. *Time*, as already stated, was the one thing that could not be given. Speed was a requisite. Everything

had to be done "immediately." No delay was allowable in anything.

Naturally, ships were forced to go to sea with green crews. Those ships already in commission at the beginning of the war did not suffer as much in this regard as the others, but they, too, had many new men on board when a full crew was secured. This was due in large measure to the fact that the crews were *increased* during the war; whatever the cause, however, the effect was crews that were heterogeneous.

At the best, with such a crew, it was impossible to obtain the best results. This was particularly true in the fire rooms. The engines would run well enough, but it was hard to get the steam to run them. The firemen were not the *best* firemen, and they were unused to the ships they were on. They could not obtain the best possible results from our boilers. Yet, better men never entered a navy than entered our Navy during the war. They were always willing, always working. They worked until they dropped from sheer fatigue, and there was no grumbling. They had to live on sea rations for the most part. It was frequently impossible to secure the ordinary fresh provisions, as potatoes, for an example, for periods of many weeks at a time. This was due to the extended and distant character of the service required of the ships. But these men, unused to naval discipline, subjected themselves completely to it.

What but a superior fire-room force furnished the steam that made a 16-knot battle ship overhaul a 20-knot cruiser? Both ships were well designed as regards the machinery. And there are other ships than the *Oregon* that would have done as well as she did if given the same advantages. I repeat, better men never were in the Navy than were in it during the war.

The conditions of the war made necessary the use at all times of full boiler power. At the commencement of the war this was due to the necessity of being always prepared for a chase; later, off Santiago, it was due to the necessity of being always on guard against such a sortie as came on July 3d. It is true that not all of our ships were maintained in this state of complete preparedness, but the *Oregon* certainly was, and this to such manifestly

great advantage that it would seem that all should have been so kept. I say this with full deference to the judgment of those that ordered it otherwise, and whose knowledge of all the circumstances was better than mine. It would appear, however, that in order to retain anything like the true efficiency of the ship, it is necessary to keep intact at all times the power of securing a full steam supply at short notice. The battle of Santiago amply demonstrated that the time allowed to get the steam to the engines is considerably less than the time required to raise steam from a cold cylindrical boiler. In all cases where the fires were not actually lighted in the boilers they were kept in readiness for instant lighting. There may have been a few exceptions to this, which is intended to be merely a statement of a general rule.

This practice of lying with boilers always in use, or ready for use, was a natural one, and will always be required for such extended service as our fleet had to perform, and, indeed, in all naval operations in time of war. When great boiler power is given a ship, it must certainly be intended for use in time of war. Its constant use, however, as thus required, entails some very serious disadvantages, which must not be lost sight of.

Lying with all boilers in use and with the fires kept clean, so as to be ready for emergencies, with steam in the engines, required the expenditure of a large amount of coal. The number of knots made each day was small, but much coal was lost in the stacks, in radiation and through the engine drains. This "standing by" costs heavily in coal. There was always, in spite of the presence of colliers with the fleet, much difficulty with the coaling question. It was often not possible to coal in the open sea, and, even after Guantanamo Bay was seized and a sheltered coaling station secured, much time was lost in coaling.

It would seem almost unnecessary to insist further on the value of coal. The battle ship *Massachusetts* lost her chance of sharing in the glories of July 3d, because she was away "coaling ship." This effect, then, of the continuous use of full boiler power was a serious one.

The work for the men that were forced to stand steaming

watches for such a long period in the intense heat of the fire rooms and engine rooms was very hard. It was not so hard as it would have been if they had had to keep the ships under full speed all this time, but it was quite as hot and it was very trying. The continued strain, with the terrible heat, bleached these men snow-white, though those on deck were tanned almost black by the tropical sun. The men from Cuba who came home after doing the work in the fire rooms, looked as if they had gone through a long spell of sickness. This was the effect of the strain due to such unusually prolonged hard work. This work was well done, but the men were weakened, and after a comparatively short time they were not capable of such exertions as they could have made at the first part of the war. Naturally this decreased the power of the ships below what it should have been, and this, too, is a very important point. The condition of the crew must be considered, both for humane reasons and because the efficiency of the ship is in question.

The use of all boilers increased the loss of feed water because the number of leaks was increased. It is not possible to determine this absolutely, but it is thought that a very large part of the loss of feed water occurred at the boilers. It very soon developed that this was a matter of vital importance. The evaporating plants were frequently insufficient to maintain the freshness of the feed water after they had supplied the necessary drinking water for the crew. This, of course, made necessary the use of salt feed as a make-up, and rendered fresh water in the boilers out of the question. The length of time that the ships were called upon to remain way from a naval base or a repair station must be considered. Evaporating plants, ordinarily ample, soon become insufficient, as a direct result of the fouling due to use.

In several cases one of the boilers was told off to do duty as an evaporator and thus limit the trouble from the use of salt water to one boiler. This measure was generally successful as far as it went, but it destroyed in large measure the efficiency of the boiler so used.

With the boilers always in use they soon become dirty, not

only on the fire side, but also on the water side of the boilers. Leaky condensers gave much trouble, and it has been seen that salt water in the boilers was a common occurrence. Now these boilers, being always in use, were inaccessible for repairs or cleaning, and much efficiency was lost as a result of the scale that accumulated upon the heating surfaces. There are several cases recorded of the dropping of the crown sheets of furnaces from this cause. In at least one case, that of the *Indiana*, a battle ship was thus disabled for a considerable time.

This matter of fresh water for the boilers gave much trouble. Even the water sent the fleet by the water boats was sometimes not satisfactory. In torpedo boats using light tubulous boilers, the dirt in the water frequently caused severe priming at high speeds, and it was not possible to use a high forced draft on this account.

Another point in the matter of the working of the machinery that must be considered is the comparatively low sustained speeds obtained. The mixed crews, with fires that soon become dirty, and that never were thoroughly cleaned owing to lack of opportunity, the dirty boilers, the terrible fatigue due to the prolonged hard work, made the combustion of coal per square foot of grate surface comparatively low. In practice it was found that the maximum speed was not far from that obtained ordinarily on natural-draft trials. By natural draft is meant real natural draft, without any blowers in use. The use of blowers just about brought up the speed to what it would have been at the start if no blowers had been used.

Many points have been only referred to that could well be enlarged upon, and doubtless other important points have been entirely omitted. To be complete would require a study and detailed consideration of each and every incident of the war, something beyond the scope of this attempt to bring forward prominently those war conditions most directly affecting the efficiency of the motive power of our ships.

The foregoing represents, however, some of the war conditions that have developed during this war, and that will again develop in any war. They are conditions that affect greatly the effici-

ency of the machinery. These conditions are facts, and they must be met and considered in making designs of war ships.

These conditions in short, with present designs, are:

1. The crew is not thoroughly efficient at best, and after a short time it is worn out by hard work and is incapable of achieving results ordinarily well within its powers.

2. Trouble is experienced from the lack of uniformity in design.

3. It is necessary, for the maintenance of proper efficiency, to keep full boiler power always in use, and this requires the expenditure of a great deal of coal.

4. The boilers rapidly become dirty and lose efficiency.

5. The boilers, being kept constantly in use, or at least ready for use, are inaccessible for repairs or cleaning. This is a cause of a great loss of efficiency, and one that will sometimes disable a ship.

6. Not more than about 25 pounds of coal per square foot of grate surface can be burned for any length of time, no matter how great a forced draft is used. It must be understood that no reference is intended to torpedo boats using a forced draft of many inches, where this figure would generally, with fresh water, be exceeded, but where the same proportion would obtain.

These are some of the war conditions that confront us. Ships of war are designed for war, and the conditions that obtain in actual war service are those that must be most considered in making such designs. These are not new conditions, but conditions the importance of which has been thoroughly developed during the war. They have passed beyond the stage of prediction and theory, and are absolute. They are conditions that are now as certain to be encountered in time of war as storms or even waves at sea.

Let us consider what is required to properly meet these war conditions:

As far as possible designs should be uniform. This applies not only to engines but also to boilers. It may be said that the length of grate cannot always be the same, but there is a length beyond which working the fires is very difficult. With a con-

stant length of grate it is possible to have a constant length of boiler tubes, and by using one diameter of boiler tubes we could have both grate bars and boiler tubes that would be interchangeable among all ships.

The evaporating plants must be large on all ships. The trouble from the use of salt water in boilers cannot be entirely prevented, as condensers will sometimes leak; but it must be reduced as much as possible. It must never occur, on account of the insufficiency of the evaporating plants, to supply make-up feed after supplying drinking water to the crew.

The boilers must have a large grate surface so that steam can be furnished with readiness to the engines. To go further, our contract-trial speeds should be obtained by burning not much more than 25 pounds per square foot of grate surface under the boilers. This would insure the ability to attain this speed, a maximum speed in practice, without great difficulty.

The boilers should be divided into small units so that it will be possible to overhaul them, one by one, without at any time making any great inroad into the steam-producing plant.

We want to avoid the great fatigue to the men, the great loss of feed water, the rapid fouling of the boilers incident to their being maintained at all times with lighted fires under them all.

We want to avoid any great expenditure of coal incident to keeping the vessel at all times in complete readiness for action.

Our boilers must be accessible to repairs and cleaning, inside and out.

To fulfil these requirements we must have boilers that are capable of generating steam quickly from a cold boiler. Such boilers could be maintained with heavily primed fires ready for lighting, but not lighted until required, and such boilers would be capable of furnishing a full supply of steam to the engines at short notice.

By the use of hydrokineters, the water in these boilers could always be kept hot.

The wear and tear on the ships would be decreased and could be controlled. The ship being fitted with such boilers, a full watch would not be required at all times in the terrific heat of the fire rooms; having the men within call would be sufficient.

The crew would not be worn out with hard work to such a deplorable extent as now obtains.

As the time required to raise steam from a cold boiler is largely due to the time required to heat to the boiling point the water contained in the boiler, in order to have boilers that will be capable of raising steam quickly, we must have boilers having a small amount of contained water as compared with the cylindrical boilers that are now in use.

The foregoing means that water-tube boilers are tactical necessities, as this type of boiler is the only one that is capable of being divided into small units, and containing a small amount of water. The arguments for and against water-tube boilers have been gone over again and again until they are threadbare, but the fact that we must have boilers that are capable of being divided into small units, and that are capable of quickly generating steam from a cold boiler, must settle the question. Whatever the faults and virtues of this general type of boiler, it must be used to satisfy the manifest requirements of the service. War conditions that we have found to exist, and that will again exist, require the use of water-tube boilers.

We find that water-tube boilers must be used on men-of-war, but we also find a great deal concerning the type of water-tube boiler that must be used.

It may or may not be capable of sustaining a high forced draft. It is not a great advantage that it should be so capable, as in the course of their ordinary use in time of war no very great advantage could accrue from this ability. They could be depended upon to burn only 25 pounds of coal per square foot of grate surface, this figure rising perhaps, in emergencies, for a short time to 30 or even 35 pounds. Such rates of combustion are, however, obtained with very moderate forced draft.

It is fortunate that this quality must not be insisted upon. The comparatively direct and unobstructed course of the gases of combustion in most types of water-tube boilers renders them uneconomical with high forced draft.

An increase in the space on board ship devoted to machinery, above the large amount already so allotted, must be avoided.

Inasmuch as the grate surface of the new boilers must be greater, for the same power developed at the engines, than that in the type of boilers now used, there would naturally be an increase in the boiler-room space required. This must be avoided; and this can only be done by increasing the ratio of grate surface to floor space occupied above that in cylindrical boilers. This ratio must be a large one, and the larger the better.

Considering the crew a ship is sure to have in time of war, and the fact that frequently the water tenders will be new to the ship and, possibly, even to the type of boiler used, the boilers must not be complex. The number of attachments must be as small as possible to minimize the work of these busy men.

No great efficiency in firing must be required to attain a good efficiency of the boiler. This follows from the fact that the firemen in the Navy in time of war are not equal to doing any particularly good firing. In time of war, locomotive and stationary boiler firemen are as frequently met in the fire rooms of our ships as are regular trained sea-going men.

The fact that no great efficiency in firing must be expected or required, means that the complete combustion of the fuel must not be attempted in one chamber above the fire. There are sure to be holes in this fire. It will not be the same thickness in one place as in another and the coal will not lie evenly over the grate. At some point, then, beyond which an opportunity for the economical extraction of the heat from the furnace gases is afforded, the gases of combustion must be thoroughly mixed and a combustion chamber furnished.

The care of the boiler while steaming must not be attended with any great difficulty. The water level must be steady. This requires a large area of cross section of the boiler at the water level and in general requires a large amount of contained water in the boiler. This amount of water must not, however, be so great as to interfere with the ability of the boiler to furnish steam quickly from a cold condition.

The parts of the boiler must be afforded a free expansion to make the quick raising of heavy fires under a cold boiler possible

without any danger of causing leaks. For the same reason, a good, free circulation of the water in the boiler must be assured.

As it is not possible to entirely prevent salt water in the boilers, they must be capable of use with salt water and the interior must be accessible for cleaning. It must be possible to remove salt and other scale from the water side of the heating surfaces. The tubes must therefore be straight tubes and not of very small diameter. Any attempt to disprove the foregoing by statements that in certain types of boilers there will be no scale deposited upon the heating surfaces that are the most exposed to the heat of the fire must be viewed with doubt. The facility of repairs of straight-tubed boilers over those that are supplied with bent or curved tubes would also call for the use of straight tubes.

The above conclusions are direct deductions from actual war experience. They must be satisfied to satisfy real war conditions.

If the reasoning has been correct from effect to cause, these are requirements that it is absolutely essential should be fulfilled to secure a proper efficiency of our war ships. They form only a part of the requirements of good water-tube boilers, but an attempt has been made only to point out certain particulars of design that are required for efficiency, as determined by the experience of this war. There are many other lessons to be drawn from the war with Spain, but the necessity for the use of water-tube boilers is the great lesson to the engineer. To know that certain qualities of this type of boiler must be obtained to insure satisfaction, is also interesting.

To have a successful and satisfactory water-tube boiler, we must have a boiler that is simple, economical under the ordinary conditions of use, with as few joints as possible. It must be accessible for repairs and cleaning. It must have large grates, not long grates, but grates that are short so as to be easily worked, and that gain area by an increase in the total width.

There have been experiments with water-tube boilers for years. There is an infinite variety of this general type of boiler. They have tubes of all shapes and sizes placed at all angles. These tubes are connected with many types of steam and water drums, placed some within and some without the boiler proper.

These boilers are supplied with feed heaters, air heaters, and all sorts of economizers. But the boiler that we want, the boiler that we must have, has certain fixed requirements of design. Many of the types of water-tube boilers fail at once to satisfy those requirements. Is there one that will satisfy them all? If there is such a boiler, which one is it? If no such boiler yet exists, what modifications must be made in that type of water-tube boiler that comes the nearest to satisfying the requirements to make it satisfactory now and hereafter? For the sake of uniform design, some one type must be found and adhered to.

THE MELTING POINT OF CAST IRON.*

By Dr. R. Moldenke.

In the rapid development of the art of founding into a distinct division of a great branch of applied science one point seems to have escaped general research, not because it was not recognized, but because the proper appliances were lacking. This is the question of melting and casting temperature, a question all foundrymen deal with daily, and which for some branches of the art means either a successful cast or an utter failure.

The question of whether silicon affects the condition of the carbon contents of a casting or not is coming up again, as it does periodically, analyses by the dozen being quoted to substantiate statements made on either side, and yet we see only an occasional statement that the temperature conditions were as nearly the same as possible. What proof is there of this? The writer has taken the temperature of a ladle of iron which to the eye seemed as hot as melted steel, and yet another ladle full of iron of a different composition, which was dull red, contained the hotter metal of the two. Again, from the same tap differences in temperature were found running nearly 200 degrees Fahrenheit. The castings made with the two extremes in this case, though of the same silicon contents, differed widely in the proportion of graphite to combined carbon for the same thickness of section.

No wonder we are told that the silicons do not play so important a part. In one of the determinations described later on, a piece of cast iron was placed side by side with some ferrochrome, both being under the same cupola conditions. The comparatively thick piece of cast iron heated quickly and melted before the thin piece of ferrochrome, though showing the melting heat of the iron, was thoroughly red hot. Thus it will be seen that the eye is no criterion of the higher temperatures.

* Paper read before the Pittsburg Foundrymen's Association October 24, 1898.

Those who cast heavy work know the danger of pouring either too hot or too cold, and many are the devices made use of to test the heat of a ladle full of melted iron. Since these methods are empirical at best, how will we know, at least approximately, the temperature of our melt? Only by a device capable of withstanding such a severe usage. In looking about for such an instrument the attention of the writer was naturally directed to the latest and admittedly best form of a pyrometer for very high temperatures, the Le Chatelier. This consists essentially of two pieces of wire of a slightly varying composition, a heating of the junction of which produces a current of electricity proportioned to the degree of heat applied. The amount of this current is measured by a suitably calibrated galvanometer, and thus the temperature may be read off at any convenient distance rapidly and with a surprising degree of accuracy.

A NEW PYROMETER.

Unfortunately, this wonderful instrument, one wire of which is of platinum, the other of an alloy of platinum and 10 per cent. of the rare metal rhodium, cannot be immersed directly in the melted iron; there would soon be an end to this expensive thermo-couple. The long porcelain tube which protects it when used in kilns is worse than useless in a ladle full of metal, and so, at the suggestion of the writer, the Pittsburg representative, the Vulcan Mfg. Co., set about remedying the matter and devising some protective cover which would allow experiments of this kind to be carried out readily. The outcome, while not having the advantage as yet of an extended period of trial, was, nevertheless, so happy a solution that it is presented to-night for the first time, and to the Pittsburg Foundrymen's Association, with the hope that much of value may be learned with it, not only in our daily work, but also in connection with the many intricate problems still before us which await solution at the hands of those willing to give their time and energy to such an exacting study.

Fig. 1 shows a section through the instrument. The platinum wire will be noticed running from the terminal box through an

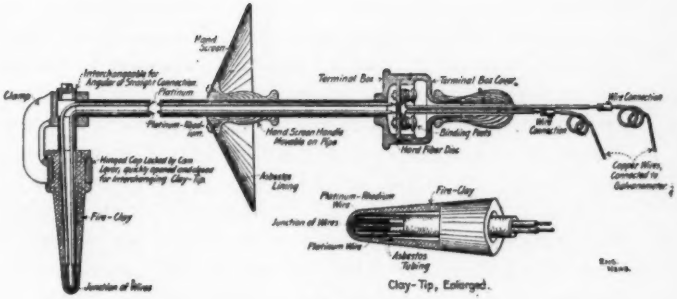

Hand Screen
Interchangeable for Angular or Straight Connection Platinum
Clamp
Terminal Box
Terminal Box Cover
Wire Connection
Platinum-Rhodium
Hand Screen Handle Movable on Pipe
Binding Posts
Hard Fiber Disc
Wire Connection
Hinged Cap Locked by Cam Lever, quickly opened and closed for interchanging Clay-Tip
Asbestos Lining
Copper Wires, Connected to Galvanometer
Platinum-Rhodium Wire
Fire-Clay
Fire-Clay
Junction of Wires
Platinum Wire
Asbestos Tubing
Junction of Wires
Clay-Tip, Enlarged.

FIG. 1.

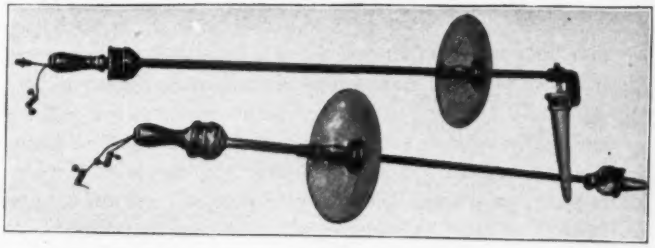


FIG. 2

iron pipe ending at the inner side of the point of the clay tip. Here is the button made by the fusion to the other wire of platinum and rhodium alloy which runs back, parallel to the platinum wire, to the terminal box. Both wires are covered with asbestos to insulate them from each other and from the iron frame, as well as to serve as a protection in case the tip breaks while in the molten iron. The interchangeable connection holding the clay tip allows it to point out straight for use in small ladles or in experimenting, or it may come down at right angles for taking temperatures in large ladles full of metal. A third form, not completed in time for illustration purposes, has a ball and socket joint, which allows the tip to stand out at any angle. A movable shield lined with asbestos protects the hand.

Fig. 2 shows two of the styles of the pyrometer, the angle and straight tip forms. In the terminal box are placed the connections which allow wires of any convenient length to run through the handle and connect with the galvanometer. The galvanometer itself is a "D'Arsonval," specially gotten up and calibrated for industrial purposes. The original form, with the reflecting mirror, and capable of reading to one-half degree at these high temperatures, was found too cumbersome and delicate for factory use.

The sensitiveness of the couple, even though protected by a refractory material, is such that plunging it cold into the melted iron the correct reading is obtained in one and three-fourths minutes. When heated up to redness beforehand, however, this time is reduced to not many seconds.

It would be beyond the scope of this paper to show the many uses to which such an instrument can be put in the steel and iron trade. On the question of annealing alone it will pay for itself in a short time, and when its capabilities in foundry practice come to be investigated and generally understood, one more safeguard will be added to those already helping us to increase the efficiency of our plants.

TEST OF THE MELTING POINT OF VARIOUS IRONS.

The material experimented with was gathered for several years, some of it being furnished by Mr. Jos. Seaman, Mr. Thomas D.

West and Mr. J. E. McDonald, members of this Association, and the especially interesting alloys by Mr. R. McDonald, of the Crescent Steel Co.

There were forty-eight pig irons, embracing both foundry and Bessemer brands as well as softeners, made with coke and with charcoal, both cold and warm blast. Seven of the fifteen cast irons were melted right from the tip. The balance were of the sand and chill rolls made by Mr. West in his recent experiments. Two steels and nine alloys of chromium, tungsten and manganese with iron, complete the list of seventy-three specimens.

The melting was done in an assay furnace converted for the time into a cupola. A jet of steam entering the stack in the side near the top induced the blast, the air being drawn in all around the bottom. In this form it is really the "Herberz" cupola of European fame and excellent for small diameters. A hole was broken into the wall just below the charging door, which must be kept closed when not used. This hole allows the introduction of the pieces of pig iron, etc. After heaping up enough coke to last for some time, the piece of pig iron (of full section and about 5 inches long), was driven into the bed, surrounded by incandescent coke, and the opening closed with a tile. After it was red hot the tile was removed, the pyrometer inserted and pushed against the center of the pig where the borings were taken for the analysis. The temperature as registered by the pyrometer rose rapidly, then more slowly, remaining stationary while the iron melted slowly. Then, as the point finally became uncovered, the temperature jumped up, going above 2,000 degrees Fahrenheit. In this way the results noted in the accompanying table were obtained.

It took much patience, a loss of a few samples, and a number of broken tips to accomplish all this, but, on the whole, the results given are as good as could be gotten under the conditions prevailing. The coke burning up would let the iron drop a little, and a failure to adjust the pyrometer to suit (the opening being closed by a piece of sheet iron, to prevent undue cooling by air drawn in), meant a break in the tip, which, while not affecting the results, caused subsequent delay and trouble.

The following general observations were made: The white irons held their shape, the iron running from the sides and bottom freely, leaving smooth surfaces. The gray irons became soft, dropped in lumps, leaving a ragged surface. Ferro-manganese samples became soft and mushy, exhibiting a consistency of putty before finally running down. Ferro-tungsten behaved most marked. As it melted it acted like white iron, but instead of chilling quickly it ran through the coke, coming down the spout in thin streams like white-hot quicksilver, only setting after collecting in a pool in the pan of sand.

The cupola was fluxed heavily with fluorspar to take care of the ash, for it was a case of a furnace full of incandescent coke and only one piece of iron in it. The accompanying tables give the results.

The tables of the pig and cast irons have been arranged according to their combined carbon contents, for it is evident that with few exceptions the melting points increase as the combined carbon goes down, this being the case independent of the amount of graphite present. One could hardly expect anything else for that matter, gray cast iron being really a steel with a lot of mechanically mixed graphite, and white iron a combination of carbon with iron. Alloys melt at a lower temperature than any of their constituents, and so also white iron, really an alloy of carbon or some carbides of iron with iron, should melt sooner than the purer iron in the gray variety.

The fact, however, that steel melts at a much higher temperature than the grayest of irons in the table, shows that there are other considerations not to be overlooked in studying the molecular physics of cast iron. The principal reason for this lowering of temperature is the supposed solution of the graphite in the iron before actual melting takes place. To what extent this occurs and under what circumstances is not known, but may account for the difference in the melting points of steel and gray iron.

Again, in melting steel in the cupola commercially, an absorption of carbon from the fuel takes place, the melting point is doubtless lowered a little, and the results obtained are tangible,

TABLE I.—MELTING POINTS OF VARIOUS PIG IRONS.

Number.	Melting point.	Combined carbon.	Graphite.	Silicon.	Manganese.	Phosphorus.	Sulphur.
	deg. Fahr.						
1	2,030	3.98	...	0.14	0.10	0.220	0.037
2	2,040	3.90	...	.28	.11	.216	.044
3	2,040	3.74	0.14	.38	.16	.172	.032
4	2,070	3.70	...	.26	.09	.198	.033
5	2,100	3.52	.54	.47	.20	.200	.036
6	2,040	3.48	...	.36	.09	.240	.040
7	2,055	3.22	.68	.71	.09	.142	.038
8	2,010	3.21	.20	.45	.18	.198	.037
9	2,110	2.28	1.14	.42	.13	.185	.026
10	2,140	2.27	1.80	.45	1.10	1.465	.032
11	2,150	2.23	1.58	.42	.16	.415	.045
12	2,170	1.96	1.90	.75	.63	.097	.028
13	2,170	1.93	1.69	.52	.16	.760	.036
14	2,170	1.87	1.85	.56	.46	.713	.027
15	2,150	1.84	1.95	.56	.34	.175	.022
16	2,190	1.72	2.17	1.88	.54	.446	.028
17	2,200	1.69	2.40	1.81	.49	1.602	.060
18	2,230	1.54	2.08	2.02	.39	.632	.062
19	2,190	1.49	2.26	2.54	.50	.349	.038
20	2,210	1.48	2.30	1.41	1.39	.168	.033
21	2,190	1.47	2.63	.89	.48	.164	.037
22	2,190	1.36	2.41	1.65	.32	.160	.038
23	2,210	1.31	2.70	1.25	.76	.170	.022
24	2,210	1.31	2.40	1.69	.46	.085	.039
25	2,230	1.24	2.68	.65	.26	.201	.020
26	2,230	1.23	2.70	1.20	.37	.299	.022
27	2,230	1.12	2.66	1.13	.24	.089	.027
28	2,200	.90	3.07	1.09	.33	.176	.014
29	2,230	.87	3.10	1.34	.42	.158	.030
30	2,210	.84	3.07	2.58	.47	2.124	.051
31	2,260	.83	3.26	1.97	.59	.210	.018
32	2,230	.80	3.22	1.30	.59	.172	.042
33	2,250	.80	3.16	1.29	.50	.218	.020
34	2,250	.80	2.89	2.21	.25	.411	.041
35	2,250	.67	3.60	1.32	.20	.205	.020
36	2,240	.59	3.15	1.50	.61	.094	.032
37	2,230	.47	2.84	2.19	.65	1.518	.042
38	2,250	.38	3.43	2.44	.57	.422	.048
39	2,250	.35	3.44	2.07	.28	.448	.039
40	2,260	.35	3.70	3.29	.82	.501	.038
41	2,260	.24	3.48	2.54	.30	.060	.020
42	2,280	.13	3.43	2.40	.90	.082	.032
			Softeners, Ferro-silicons and Silico Spiegel.				
43	2,190	3.38	.37	12.30	16.98	...	...
44	2,040	1.82	.47	12.01	1.38	...	...
45	2,090	2.17	.72	10.96	1.34	...	...
46	2,155	1.35	1.60	9.40	.32	...	...
47	2,145	1.57	1.36	8.93	.39	...	...
48	2,170	1.77	1.80	4.96	.39	...	...

even though care must be taken to get the whole of the charge down before pouring. In the air furnace the steel absorbs carbon by contact with the pig iron charged and melts off, the wasting of wrought iron or steel poking bars used for rabbling giving evidence of this occurrence.

TABLE II.—MELTING POINTS OF VARIOUS CAST IRONS.

Number.	Melting point.	Combined carbon.	Graphite.	Silicon.	Manganese.	Phosphorus.	Sulphur.	Remarks.
	deg. F.							
49	2,000	4.67	.03	.57	.22	.266	.044	Cast into chill roll (Mr. West).
50	1,990	4.20	.20	.63	.33	.254	.040	" " "
51	2,010	4.08	...	.89	.06	.287	.040	" dry sand.
52	2,000	3.90	.16	.75	.66	.240	.030	" chill roll (Mr. West).
53	2,030	3.62	...	.72	.14	.193	.026	" dry sand.
54	2,030	3.48	...	.47	.09	.190	.032	" "
55	2,040	3.40	...	.42	.07	.196	.029	" "
56	2,170	1.63	2.27	1.46	.50	.092	.032	" "
57	2,210	1.60	3.16	.59	.25	.271	.048	No. 48 in sand rolls (Mr. West).
58	2,250	1.57	2.90	.66	.31	.237	.040	No. 49 " " "
59	2,240	1.22	2.66	1.69	.47	.274	.037	Cast into dry sand.
60	2,250	1.20	2.90	.75	.66	.248	.030	No. 51 in sand rolls (Mr. West).
61	2,260	.17	3.57	2.09	.43	.272	.042	Cast into green sand.
62	2,080	1.95	1.28	11.64	.98	...	...	Remelted ferro-silicon No. 5, cast into chill roll (Mr. West).
63	2,080	1.81	1.36	11.70	1.00	...	...	Remelted ferro-silicon No. 5, cast into sand roll (Mr. West).

The writer is especially pleased to see the full corroboration of Mr. West's elaborate experiments with the melting of white and gray irons. The contrast is remarkably sharp, and on the whole it shows us that science and practice go hand in hand admirably, no matter what the field may be. Whatever theories may develop regarding the melting of iron, whatever the effect of high or low phosphorus, silicon, manganese and sulphur may be shown to be on the melting point of an iron eventually (the present series of irons not being well enough adapted for this phase of the question), the results here given are, it is hoped, of sufficient value to stimulate further research of practical value to the founders of cast iron.

A COMPARISON OF THE HOLLOW-BORED METHOD AND THE FLUID-COMPRESSION HOLLOW-FORGED METHOD OF MAKING STEEL FORGINGS.

By Geo. H. Briant, Assoc. M. W. S. E.

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In presenting this paper before your society it is not my intention to deal in detail with the many processes of manufacturing hollow-bored shafts and steel forgings, as the various methods have previously been extensively presented and discussed.

Some of the papers, however, I believe, have laid too great a stress upon certain processes that are more to the advantage and benefit of the producer than to an increase in the merit of the finished material produced, and it is my intention to show why the Krupp Works, after having experimented with the different processes, adhere to their present method.

The process that has been most thoroughly and elaborately submitted is undoubtedly that used to produce fluid compressed steel, and the Krupp Works a number of years ago made extensive and careful experiments with this method of making ingots for heavy forgings, and it is a noticeable fact that to-day they are using their method of casting a larger ingot than is cast by other manufacturers, and do not in any way use the fluid compression.

The Krupp ingots, however, are cast three times the diameter of the finished shaft, while the most modern works cast ingots of but twice the diameter the shaft is to finish.

Segregation, of course, takes place in the center of every ingot, large or small, and, as is admitted by the advocates of fluid compression, is not prevented by that process.

Further on I will state how piping is prevented by the Krupp method, but first I will say that a longer section of an ingot can undoubtedly be used for the forging by the steel maker using the fluid-compressing process, for the hydraulic pressure must force the gathering air or gas cells higher in the mould than the ordinary static pressure does. This is an economical result, however, of benefit to the manufacturer only, the character of the material in the melting charge and the subsequent forging and treatment being responsible for the character of the finished steel and its merit.

For many years the Krupp Works, and recently most of the works in this country, have used hydraulic forging presses for the manufacture of the largest shafts, as the material can be thoroughly worked by this process only, being a most important point for the strength of the shafts, and for this purpose the Krupp Works at the present time are equipped with a large number of hydraulic presses of different capacities from very small up to those of 5,000 tons effective power.

At the Krupp Works, as above stated, the rule observed is that the diameter of the ingot must be three times the diameter of the finished shaft, while it is understood that the most modern works in the United States forge from an ingot but twice the diameter of the finished shaft. By the Krupp rule, an ingot is drawn out to the high degree of 9 to 1 as against 4 to 1 by the process employed in this country.

At works which forge hollow, a hole is bored through the ingot of the diameter of the bore of the finished shaft, consequently necessitating the cooling down of the ingot before being forged.

Even if the ingots cool down very slowly, this method, nevertheless, involves considerable risks, as the strains which are unavoidably produced in the ingot, in this condition of largely crystalline structure, are likely to cause cracks. The reheating of the ingot is, for the same reason, unreliable, even if the greatest care be taken.

For these reasons, at Krupp's Works all large ingots for shafts and other heavy forgings are never allowed to cool down after

casting, nor during the process of their manufacture, but are kept hot until the working of the forgings under the hydraulic presses has been completed.

By working the ingot from its original heat, the detrimental effects from piping are removed, as the strains causing piping are not allowed to generate, owing to the working from the hydraulic press both by compression and drawing out.

As to the most important advantage realized by boring out the ingots as done at works which practice forging hollow, is that in this way a part of the casting is removed to which the greater part of the impurities, such as phosphor, sulphur, manganese, etc., have segregated, it needs probably no further explanation that this end is attained much more effectively by Krupp's method in boring out the solid forged *shaft*, than by the process where the *ingot* is bored out, before having them forged down, in consequence of which a much smaller percentage of the impure material is bored out.

In the case of the crucible steel employed at Krupp's Works for shafts these segregations are of much less importance than in the case of open-hearth steel, which, according to a paper recently read before this society, can be qualified as high-grade steel only if it contains not more than .04 of 1 per cent. phosphor, sulphur and other impurities, while Krupp's crucible steel contains less than .02 of 1 per cent. of phosphor, sulphur, etc.

While some works resort to the fluid-compressing process in order to overcome the blowholes produced by the air and gases entrained into or generated in the casting, and to minimize the detrimental effect of these blowholes, I do not intend to dispute the efficiency of this process for obtaining the results aimed at. The experience of many years, however, and of numerous investigations with ingots of the largest size, entitles Krupp to the assertion that he employs a most excellent process of his own for producing solid castings, and results of comparative experiments have pronounced in favor of the Krupp method as being much more efficient than the fluid-compressing process.

In regard to the question as to which material is the best and most reliable for shafts, it should not be omitted to point out the

many advantages which distinguish Krupp's crucible steel from any other kind of steel produced by any other process, for crucible steel has just those qualities which make ingots proper for such forgings as shafts. The superiority of this material is founded upon the arrangements designed especially for this purpose, and furthermore upon the practice of many years which guarantees the complete control of the process, and especially the ability of charging thousands of crucibles uniformly, filling them exclusively with puddled iron and steel, manufactured especially for this purpose, by being repeatedly refined and freed from cinder by welding, hammering and rolling and by picking out by experienced workmen. Krupp is further enabled, by means of the iron mines and blast furnaces which he owns, to always obtain the best raw material, and to charge every crucible exactly the same, so that at the very outset a determined hardness and quality can be expected with confidence.

The melting furnaces have been improved to such a high degree that the greatest precision in the attainment of the required heat in all the furnaces and in all crucibles necessary for one ingot is guaranteed.

A further advantage of the crucible process is the complete absence of the detrimental effect of the furnace gases, cinder, oxygen and other gases in the molten steel, an indispensable condition for the production of solid ingots, and a condition that requires no fluid compressing to doctor up. The existing arrangements permit the casting of ingots of crucible steel up to 85 tons, which maximum has hitherto been more than sufficient for the largest shafts likely to be ordered.

Regarding the process of forging hollow upon a mandrel, it may here again be pointed out that the selection of a much larger ingot at Krupp's Works, which allows a forging down of the cross-section of the ingot from 9 to 1, surpasses completely the advantages, if there be any, of hollow forging, especially so if the forgings are bored out after having been forged under the presses than if, as is done at some works, the ingots are only drawn out from 4 to 1.

Never having seen the report of a test piece taken from the in-

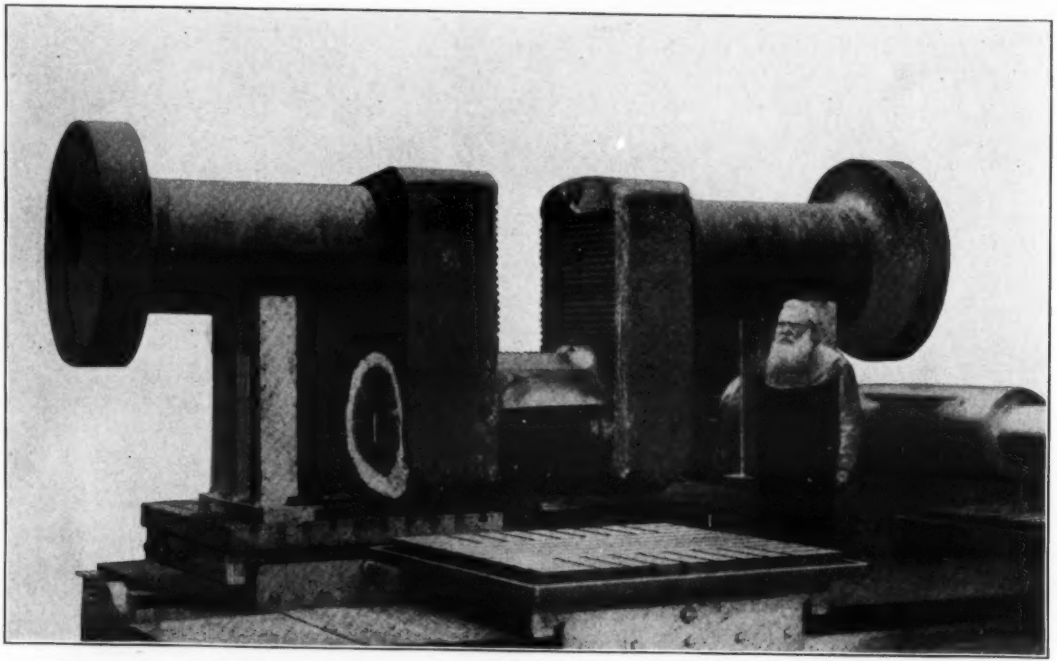
side wall of a shaft that has been forged hollow on a mandrel, I cannot say that it is not as dense as the inside wall of a shaft that has been cast solid, forged and then bored. But theoretically I cannot see why it should be, as the mandrel does not act as an anvil or die, since the shaft being forged is not suspended upon the mandrel, but rests upon the press die, from which point the resistance is offered to the forging pressure applied.

If the metal in the center of a *solid ingot* is not compressed by hydraulic forging, the mandrel in a *hollow* ingot would be only a useless substitute for the core removed. If the center or core of a solid ingot *is* compressed by the forging press, it is decidedly a better method to forge to the center the greater volume of impurities and afterward remove them by boring, as per the Krupp method, than to remove only a portion of them and forge the rest into the shaft, as *must* be the case if the mandrel is at all effective.

The origin of the hollow shaft is supposed to have been at the Krupp Works, and no other maker has made as many, nor any that have given greater universal satisfaction; but he does not deviate from the principle of casting solid, then forging and next boring.

Furthermore, the oil tempering and annealing to which, of course, at Krupp's Works nearly every shaft as well as nearly every forging is subjected after having been bored out, outweighs and even surpasses to a much higher degree the advantages claimed of greater density and finer grain from forging hollow, and the arrangements for oil tempering and annealing forgings of the largest dimensions can be considered as a standard, and the practice in the treatment of the different qualities is assisted very efficiently by the most improved apparatus for measuring the temperatures.

The certainty in the control of the crucible process guarantees the production of a material of higher tensile strength, without diminishing the ductility and toughness. There have been supplied for use in the United States a great number of shafts of the largest dimensions, the elastic limit of which was specified to be 45,000 pounds per square inch, with an elongation of 18 per cent.



CRANK SHAFT OF S. S. "KAISER FRIEDERICH III." WEIGHT, ROUGH MACHINED, 33,069 POUNDS. MADE BY KRUPP.

in 10 inches, and in all cases these minimums required for elasticity and elongation were considerably exceeded.

It may be here mentioned that at Krupp's Works nickel-steel is used on a large scale for the production of shafts for steamers, also for axles and crank axles for locomotives, etc. A short time ago the Krupp's Works turned out some nickel-steel shafts for the large, fast steamers which have been built for the North German Lloyd line. The ingots from which these shafts were forged had a diameter of 72 feet and weighed 60 tons each; the diameter of the crank shaft is 24 inches, and the weight of a single crank, bored and finished complete (three cranks to each engine), is 14 tons, while in the forged state the weight was 28 tons, or twice the weight of the finished shaft.

The following are the results of the physical tests of the above material made by experts of the company:

Tensile strength, . . .	85,000 pounds per square inch.
Elastic limit, ...	60,000 pounds per square inch.
Elongation, ...	20 per cent. in 8 inches.
Contraction, ...	55 to 60 per cent. and more.
Total length, ...	4 feet.

Several extremely large hollow-bored, oil-tempered, crucible steel shafts have been furnished by the Krupp Works for service in the United States, from which test bars 2 inches in diameter, 48 inches long, tested at the Watertown Arsenal by the United States Government inspectors, showed an ultimate tensile strength of 97,780 pounds, and an elastic limit of 64,000 pounds per square inch, and a reduction of area at point of fracture of 51 per cent. and elongation in 48 inches of 6.67 inches.

The usual quality of open-hearth and crucible steel furnished by the Krupp Works for crank pins, piston rods, connecting rods, etc., when no specifications are furnished will test about as follows:

Crucible Steel: Tensile strength, 78,000 pounds per square inch; elastic limit, 50,000 pounds per square inch; elongation, 22.6 per cent.; measured on 8 inches length.

Open-hearth Steel: Tensile strength, 72,000 pounds per square

inch; elastic limit, 42,000 pounds per square inch; elongation, 22 per cent.; measured on 8 inches length.

A 1 inch square section of either piece will bend double, cold, without showing fracture.

I therefore believe that we find Krupp's material, arrangements and methods outweigh all the advantages which some works claim to have realized by their method of forging hollow, and guarantee these advantages at least in the same, if not in a much higher degree. This is established by the favorable experience with Krupp's shafts in service during a great number of years, and the fact that a great number of shafts of Krupp's material have taken the place of broken shafts of other makes, some of which were fluid-compressed steel.

In regard to Krupp's open-hearth steel, it may be stated that Krupp has the best material at his disposal in the shape of scrap and turnings resulting from the extensive production of crucible steel, and it can be asserted in this respect that Krupp's open-hearth steel is not surpassed by any other steel made by the same process, but that, on the contrary, this steel can be stated to be of the best quality, and there exists scarcely any other manufacturer who has at his disposal such an excellent and pure scrap material.

At Krupp's Works there are altogether twenty-one open-hearth furnaces, partly for the basic process and partly for the acid process, varying in size from ten to forty tons' capacity, and with a total capacity of 300 tons. The largest ingots likely to be demanded can, therefore, be cast.

Written Discussion.

Mr. H. F. J. Porter.—This paper, as it is presented, is somewhat contradictory in its purport. It begins by saying that it is not the writer's "intention to deal in detail with the many processes of manufacturing hollow-bored shafts and steel forgings, as the various methods have previously been extensively presented and discussed." After this, the whole paper is devoted to criticising the details of these very processes. This criticism is based

on what seems to be such evident misunderstanding of the principles involved in the working of these processes, that I deem it only right to correct it for reference in the records of the Society.

The writer also says that it is his "intention to show why the Krupp Works, after having experimented with the different processes, adhere to their present method." I have failed to find the promised explanation, however, and therefore I presume that it is covered solely by the assertion that "Krupp's material, arrangements and methods outweigh all the advantages claimed by others, this being established by the favorable experience with his shafts in service during a great number of years, and the fact that a great number of shafts of his material have taken the place of broken shafts of other makes." As there are, however, plenty of other manufacturers who can make such an assertion as the above, it means very little. Probably as many of Krupp's forgings have been replaced by those of other makes as the reverse. There are other manufacturers, beside Krupp, who own their own mines, blast furnaces, etc., and there is no reason why, if it can be shown that their methods of manufacture are equally good, their product should not be equal to that of Krupp.

I am not a little surprised, however, to see in this paper an attempt made to defend old practice, especially in the face of the fact that it is rapidly being superseded by more modern methods, even by Krupp himself. The latter has not been an originator, but has, from time to time, adopted the methods of others as improved processes have been brought out. In fact, he has followed English practice most consistently, as may be seen from the following figures, those referring to Krupp being taken from a pamphlet, entitled "Fried. Krupp. Statistical Data," furnished to me by Thos. Prosser & Son, of New York City.

Crucible steel was invented by Daniel Huntsman, in England, in 1741; its manufacture was subsequently taken up in 1811 by Krupp. Nasmyth invented the steam hammer, in England, in 1842, and its use was common there and in France before it was taken up by Krupp. His fifty-ton hammer, so well known the world over, was built in 1861. The Bessemer process, invented in England in 1856, was introduced at Krupp's in 1864. Open-

hearth steel, in common use in England in 1867, was introduced at Krupp's in 1889 and 1890. Hydraulic-forging presses, in use at Whitworth's, in England, in 1856, and in the United States in 1888, were taken up by Krupp only in 1890 to 1892. Hollow shafts were made in England long before Krupp took up their manufacture.

Yet, although Krupp has shown himself to be very slow in adopting improvements projected by others, it must be acknowledged that when he does take them up, the skill with which he handles their details commands the admiration of the world.

Crucible steel, when properly made, is of high grade; but, owing to the large number of crucibles—thousands, sometimes, according to this paper—in which the metal composing a single ingot is melted, the product is not always uniform. The pouring of the contents of these crucibles into the ladle or mould is attendant with the oxidation of the metal, which is by no means beneficial. The handling of so many crucibles also requires the greatest skill and care. In overcoming these difficulties much expense is entailed, and as equally good forgings can be obtained from the "open-hearth" product by modern appliances, and at much lower cost, the latter is rapidly replacing it, even at Krupp's own works.

There has never been any question regarding the excellence of Krupp's highest grade of crucible steel—the only grade mentioned in the paper. The writer, however, compares the quality of Krupp's oil-tempered crucible steel with open-hearth steel hollow forged. These grades are not by any means comparable. Krupp's crucible steel oil-tempered, or his nickel-steel oil-tempered, can be compared to open-hearth nickel steel fluid-compressed and oil-tempered made by other manufacturers. These are of the same quality, have the same physical properties, and the latter is much the cheaper. Krupp's open-hearth steel can be compared with the open-hearth steel made by others, both as to grade and price.

There is nothing very remarkable in the physical properties shown in the tests referred to in the paper. They probably were not taken from prolongations taken from the forgings themselves, however. No manufacturer would forge a prolongation

48 inches long on the end of a shaft to take a test from, when he could get it from a bar 2 inches long at a small fraction of the expense. Tests equal to those mentioned and taken from forged prolongations of forgings have to be met daily by manufacturers in this country, to meet U. S. Government specifications and those of representative engineers. The U. S. Government requires steel for forgings to contain not more than .04 of one per cent. phosphorus and sulphur, and steel which will show such excellent results as were brought out prominently by the performance of the engines and guns of the U. S. S. *Oregon* and other vessels of the Navy during the recent unpleasantness with Spain must be acknowledged, even by the most prejudiced, to be high grade. In these days of enterprize and progress, however, grade is simply a matter of price.

There was a time, years ago, when steel making was a trade with which it was considered undignified for people with brains to be connected, and when smelters, rollers and forgemen were paid high prices for the skill and secrets of manufacture which they were supposed to possess. Nowadays, however, education, through the medium of scientific institutions, the technical press, engineering societies, etc., by disseminating metallurgical knowledge, has raised steel making to an art to which the greatest minds of the times have devoted their best energies. If the Chinese government should to-morrow decide to erect in the center of their dominion a steel works capable of turning out the very finest product, it would only be a question of money and a short time before steel forgings could be turned out there the equal of those produced anywhere in the world.

I note an unfortunate use of words in the following expression —"A further advantage of the crucible process is * * * a condition that requires no fluid compression to doctor up." In the face of this remark, what is intended by the assertion, "The experience of many years, however, and of numerous investigations with ingots of the largest size, entitles Krupp to the assertion that he employs a most excellent process of his own for producing solid castings, and results of comparative experiments have pronounced in favor of the Krupp method as being much

more efficient than the fluid-compression process." More efficient in what? Doctoring up? As there seems to be a desire on the part of the writer to relegate the Krupp method to the realm of mystery, it cannot be discussed here intelligently. I wish, however, as both the fluid-compression process and Krupp's secret process are comprehended under the same category, to say that there are two ways of doctoring up; one by prevention, an ounce of which, the old saw has it, is better than a pound of the other, viz: cure. Under the first of these ways comes fluid compression, with 7,000 tons of tendency towards prevention. Whether Krupp's secret method comes under this or not, no effort is made in this paper to inform us.

From another paragraph, however, where the writer says, "It is a decidedly better method to forge to the center the greater volume of impurities, and afterwards remove them by boring, as per the Krupp method," it would seem that the method referred to does not tend to *prevent* segregation, and it is extremely doubtful whether any method, secret or otherwise, can cure it subsequent to the forging, which immediately follows.

There are, however, no mysteries nowadays in steel manufacture, and the fluid-compression process is universally conceded to be very efficient, and the best known for producing solid and homogeneous steel.

Taking up for consideration that part of the paper which is devoted to the criticism of various processes which the writer says are not in use at Krupp's works: In the first place, reference to the "fluid-compression" process is so evidently based on an inadequate idea of its working that a mere reference to actual conditions will set it straight. All properly equipped fluid-compression plants have their moulds so constructed that air and gases can escape at vents located along their sides, even near the bottom. The type of fluid-compression plant, where the air and gas cells were forced to the upper part of the mould, was the first made, and was improved upon as described years ago. If Krupp has confined his experiments to *that* type of machine, it is not to be wondered at that he has failed to make it work satisfactorily. Fluid compression does not *entirely* prevent segrega-

tion, but it does *retard* it, and a fluid-compressed steel ingot, bored for hollow forging, *has no segregation.* All solid ingots segregate to their center, whether fluid-compressed or not; the amount of this defect being proportionate to the diameter of the ingot, so that ingots three times the diameter of the finished forgings, which this paper says is the rule at the Krupp Works, would, other conditions being the same, have an exceptional amount of segregation to be taken care of.

I am afraid that the writer has been misinformed regarding the size of ingots used by Krupp. The excessive amount of segregation, together with the grave disadvantage of handling unnecessarily large masses of steel, would not be compensated for by the additional amount of work put into the metal by the forging process. A crank shaft, however, is shown as evidence of this rule, viz: 24 inches diameter from a 72-inch ingot. The crank web in this shaft is the part which determined the size of the ingot, and in reality the ingot mentioned is one of unusual shape from which such a forging would be made, viz: 72 inches diameter by 110 inches long.

Recently shafts were forged in this country, 37 inches in diameter with a 16-inch hole through them. These required a 5,000-ton press to work them down from the hollow ingot. Had they been made from a solid ingot, a much heavier press would have been required to forge them. If a solid ingot had been used three times the diameter of the finished shaft, or 111 inches in diameter, a 15,000-ton press would have been needed. Such a press Krupp does not possess. What does he do when confronted with such conditions?

With reference to the critical comparison of hollow forging and solid forging and boring, the fact that there is absolutely no segregation left in a hollow ingot to be subsequently forged into a hollow shaft leaves it very doubtful to my mind whether Krupp's method of forging the segregation into the center and then boring it out can be considered as sure a method of getting rid of the segregation, particularly where the amount of segregation is as great as it would be in an ingot three times the diameter of the finished forging. I cannot see that the act of forging a

solid shaft would drive the segregation to the center, as the latter is already occupied by other metal. I should suppose, rather, that the segregation would be pretty well disseminated throughout the shaft. Tests show that this is, in fact, what takes place, and has led to the more modern process of hollow forging on a mandrel.

Had the writer seen tests of bars taken from the side wall of a shaft which has been forged hollow on a mandrel he would not have been led into the error of supposing that the cold hard core presented by the mandrel would have a different effect from the hot (and therefore soft) core presented by the center of a solid ingot.

I give some tests herewith, so that he will not fall into a similar error again:

PROPELLER SHAFT OF U. S. S. *IOWA*.

	Tensile strength.	Elastic limit.	Elongation.	Contraction.
			Per cent.	*Per cent.*
Outside Bar No. 1	96,770	60,090	23.85	54.56
Outside Bar No. 2	98,800	61,110	22.50	56.44
Inside Bar No. 1	97,270	61,110	24.55	57.74
Inside Bar No. 2	97,150	60,130	23.85	54.10

The writer is totally at variance with theory and experience when he says that keeping ingots hot prevents "piping." This defect is produced in the ingot during the process of solidification of the molten metal; and, inasmuch as an ingot cannot be removed from its mould until it is solid, all piping that is going to form has been formed before it is subjected to the process of continued heating to which Krupp's ingots are subjected. Krupp, however, is not the only manufacturer who keeps his ingots hot until used. Wherever practicable, other manufacturers adopt the same practice. The dangers attending the reheating of *solid* ingots do not, however, apply to *hollow* ingots, as already explained in my previous paper on "Steel Forgings," so that the criticism on this subject is invalid.

Both Krupp and other manufacturers are working with the same ends in view, viz: first, to improve the quality of their out-

put by whatever methods are best suited for their purpose, and, second, to reduce the cost to the consumer. Each manufacturer pursues these objects in his own way and, as a result of the enterprize and intelligence which has been expended on the art, as excellent forgings can be procured to-day in this country, in England and in France, as can be obtained from Krupp in Germany.

CLOSURE.

By Geo. H. Bryant, Asso. Mem. W. S. E.—Replying to Mr. Porter's criticism, will say that my statement, "that Krupp's material arrangements and methods outweigh all advantages claimed by others," etc., I believe to be pertinent in discussing this subject, for the Krupp Works owning or controlling about six hundred ore mines in addition to their own coal mines and blast furnaces in the various countries of Europe, every stage of manufacture is under their own supervision, and they are not dependent on the open market for a miscellaneous assortment of crude material, and their different grades of steel can, therefore, always be relied upon to be of the same uniform quality. If there are "plenty of other manufacturers who can make such an assertion" I have never heard of them, and I fear Mr. Porter is making a very broad statement. It is a well-known fact, of course, that certain ores are fitted only for certain grades of steel, consequently the great number of mines that are owned by the Krupp Works, and, therefore, the great variety of ores, enable them to select such ore as is fit for the steel to be produced and to make very careful selections from this particular grade of ore. The "old practice" I am defending is, indeed, an old practice of making steel. However, the Krupp Works are the only works today that have carried it to perfection, and the only works that can cast an ingot from an unlimited number of crucibles and produce a homogeneous steel. The largest ingot that has ever been cast by any other works that I know of was cast in England from ninety-five crucibles of 45 pounds each. I am careful to state a homogeneous steel, for it is well known that experiments have been going on in a very large number of the steel plants of the

United States in the casting of large crucible steel ingots for a number of years, and none have been successful in making a homogeneous steel, as has been proven by the product that has been produced and used. In fact, the Krupp Works are the only works in existence that can pour from an unlimited number of crucibles, as stated in my paper, and produce a uniform steel. While Krupp is not the inventor of crucible steel—he does not assert that he is—ever since its invention he has, however, always been able to cast a larger block of steel than any other steel maker, and produce a homogeneous metal, as is shown by the following list of exhibits of crucible cast-steel blocks, with the various dates of the expositions where he has always taken the highest awards.

1851 in London a block weighing 2¼ tons.
1855 in Paris a block weighing 10 tons.
1862 in London a block weighing 20 tons.
1867 in Paris a block weighing 40 tons.
1873 in Vienna a block weighing 52½ tons.

The last block, exhibited in Vienna, weighing 52½ tons, was made from 1,800 crucibles, each containing about 60 pounds. It was worked under a 50-pound hammer to show the malleability of the material, and cuts were made in four different places while in a red-hot state to show, when broken off later, the soundness and density of the casting. Since this casting, made in 1873, Mr. Krupp has cast many crucible-steel blocks much larger and always obtained homogeneous steel from them. As Mr. Porter states, the pouring of this large number of crucibles is indeed a skilful process and a process which Mr. Krupp has guarded carefully for a number of years. The Krupp crucible steel is always uniform and homogeneous, regardless of the number of crucibles cast, even though he does not claim to have originated, as might be supposed from Mr. Porter's criticism, every form of steel or machinery invented. Krupp, however, originated the hollow-bored shaft, though I erred in stating that I supposed it to have been at the Krupp Works. I will say now, however, that the first hollow-bored shaft was a Krupp shaft bored under the direction of a Krupp engineer to remove a slight check that was developing in the center of a solid shaft.

The shaft was placed again in service with entirely satisfactory results. Whether this work was done at the Krupp Works, in Essen, or elsewhere, I cannot state definitely, or whether Mr. Krupp immediately thereafter took up the manufacture of hollow-bored shafts; but it establishes the fact that he did originate the hollow forgings. In controverting Mr. Porter's further positive statement that Mr. Krupp has not been an originator, I beg to call his attention to probably one of the most successful inventions in the steel industry, that of manufacturing weldless steel tires, patent for which was granted Krupp in 1853, a style of tires that was first introduced by him in the United States, and from which time has maintained the highest grade of perfection, as a large number of consumers in the United States and elsewhere can testify. The tests submitted in my paper I believe to be "remarkable" only because they represent the usual grades of steel furnished by the Krupp Works. Whether they were all taken from prolongations, I am unable to state, but presume they were, as it is the usual custom at the Krupp Works. They do not advocate the testing of pieces of less than 8 inches, as the percentage of elongation is too great in a 2-inch piece to be at all accurate. The difference in the elongation in a 2-inch and an 8-inch piece being, in wrought iron, about 30 per cent., and in forged steel about 10 per cent. greater than in wrought iron, the difference being in favor of the 2-inch test piece.

Referring to his criticism as to segregation, will say that I think he is mistaken, as segregation in an ingot does not increase in proportion to the increase of the diameter of the ingot. But it is a well-known fact that in large ingots segregation is more observable and pronounced in the center than in a small ingot; this should not be construed, however, to mean that it increases in area throughout the ingot in proportion as the diameter increases. Segregation takes place in the last part of the ingot to cool, and in a large ingot containing a proportionate quantity of the materials causing segregation, it must necessarily be more pronounced in the heart of the ingot, but it will not increase in area in proportion as the diameter of the ingot increases, though

it may increase in quantity in proportion as the total weight of the ingot is increased.

The writer has not been "misinformed regarding the size of ingots used by Krupp," and it will, therefore, be seen that in drawing out in the ratio of 9 to 1 that the amount of segregation forged to the center of the ingot and there drawn out in being forged down, is not the serious problem that the criticism might lead one to believe; nor is the danger from piping as serious as in an ingot that is forged down from 4 to 1, owing to the fact that it is being worked before it has cooled in its center. Mr. Porter is entirely wrong when he states that an ingot cannot be removed from the mould until it is solid; and, that as piping is formed while the ingot is solidifying, which we, of course, know is entirely true, that the Krupp processes will not tend to prevent piping. It is well known that the interior of an ingot remains in a liquid state long after its outside has solidified sufficiently to be removed from the mould, and Mr. Porter doubtless knows there are many methods used to partially solidify the ends of an ingot so that it may be removed from the mould while the center or heart of the ingot is still in the fluid state, and placed in a hydraulic press where it can be held in compressive stress graduated in accordance with its temperature with an ever-increasing pressure that will, to a great extent, prevent piping taking place, and an ingot may be forged down and drawn out with but the slightest appearance of piping in its heart, which is afterward removed by boring.

In reference to forcing all gathering air or gas cells higher in the mould, I, of course, knew before making this statement of the arrangement of vents in the mould; but even with these vents I still believe that the general movement of gas in steel under pressure is toward the top of the mould, and I do not intend to convey the idea that this was the sole action of the gas.

The dimensions I have given of the crank shaft for the North German Lloyd Steamship, and referred to in Mr. Porter's letter as probably incorrect, are correct both in the ingot dimensions as well as in the finished shaft dimensions. The flange on the end is the only portion that has not been forged down from

three diameters to one, but which has been forged down to the usual dimensions of other makers, of two to one, though every other part of the shaft has been forged from three diameters to one, as stated is the universal custom at the Krupp Works.

The tests submitted by Mr. Porter from the propeller shaft of the United States Steamship *Iowa* shows the usual benefit derived from forging any piece of steel, but I do not see it proves the benefit derived from the use of the mandrel. Mr. Porter errs in stating that Krupp is rapidly replacing his crucible method with the open-hearth process because of the great carefulness and expense involved in making crucible steel; for this is not a fact, as Mr. Krupp is increasing his crucible output rather than decreasing, and is making to-day a finer grade of crucible steel than he has ever manufactured before. He is undoubtedly making a higher grade of open-hearth steel, but his open-hearth process is not replacing or substituting his crucible process, as a visit to his works will very quickly show.

WHAT IS THE EFFICIENCY OF AN AIR COMPRESSOR?

By Frank Richards.

[Reprinted from "American Machinist," October 6, 1898.]

The following question has been brought to my notice:

"Assuming that there is no mechanical friction to an air compressor or blowing engine, and that the machine is compressing air to a pressure of one atmosphere by gage, or two atmospheres absolute, what is the possible efficiency of the machine if it does not compress the air gradually? The writer has in mind a rotary pressure blower, which should not properly be used for an air compressor; but, assuming a blower to be frictionless and to have no leakage, and, disregarding the loss by radiation of heat, what would be the possible efficiency of the blower in compressing to one atmosphere?"

The question is one which might very naturally shape itself in the mind of a good mechanic who is just beginning to look into the operation of air compression. We have to assume that the air is compressed for some power transmission purpose, and it is therefore a question of the loss of power in the operation of compression, or a question of the power cost of compression. We cannot, as suggested, disregard or ignore the radiation of heat, as the question of efficiency depends entirely upon temperature conditions. Leaving out all consideration of friction and leakage, the entire range of possible efficiency in air compression lies between the compression of the air at initial and constant temperature, or isothermally, and its compression without abstraction of heat during the compression, or adiabatically.

In compressing air isothermally in a cylinder traversed by a piston, the mean effective pressure or resistance for the stroke when compressing to two atmospheres, or, say, 15 pounds gage,

and including not only the compression of the air, but its expulsion or delivery into the pipes, is 10.33 pounds. For the same operation, if conducted adiabatically, or without any cooling of the air during the operation of compression, the mean effective pressure is 11.51 pounds. As isothermal compression represents perfect efficiency, the relative cost of adiabatic compression is shown by dividing the one M.E.P. by the other; thus: $11.51 \div 10.33 = 1.114$. The power cost of compressing air to 15 pounds gage cannot, therefore, be made to rise more than 12 per cent. above perfect efficiency, so far as the air itself is concerned. The other losses in compression are those of friction and leakage, which can only be ascertained by actual tests, and in the above question we are not invited to look into them. The relative efficiency of a rotary blower as compared with a reciprocating piston machine is all comprised in their differences of friction and leakage, as the air will require the same power for its compression by either means.

The suggestion as to compressing the air gradually is the suggestion of a still rather widely held fallacy. By gradually is rather meant slowly, and the assumption is that if air is compressed slowly enough it will not be heated as much by compression, if, indeed, it is heated at all. The air will be heated precisely the same whether compressed quickly or slowly. If it remains cooler under sufficiently slow compression, it is only because it is actually cooled, or gives off heat to the walls of the cylinder, or whatever it may be in contact with during the compression. There is no saving of power by slow compression over rapid compression except by some cooling of the air that may ensue by the equivalent heating of the cylinder and piston.

The loss by radiation of heat is not a loss but a gain, or saving of power, if it occurs during compression, but is a distinct loss of power after compression and delivery of the air is completed, on account of the consequent reduction of the volume or pressure of the then available compressed air. If the air can be applied to the use for which it is intended before it loses its heat of compression, or when it has lost only a portion of that heat, so much power is saved. For this reason it is not usually

satisfactory to consider the efficiency or economy of any given case of air compression without at the same time considering the conditions under which the air is subsequently employed.

If air could be compressed isothermally and then completely re-expanded isothermally, while exerting its full expansive force against a piston, no loss of power would be sustained at either end of the operation, so far as the action of the air was concerned. This is, however, an impossible condition, either in the compression or in the re-expansion of the air. In the case before us, when compressing air from one to two atmospheres the M.E.P. for adiabatic compression may be taken to be the actual M.E.P., as, when compressing at the speed that would be commercially possible, there would be no appreciable cooling of the air during the operation. Some hydraulic air compressors, in which the air that is being compressed is intimately mixed with the water, do compress the air nearly isothermally, but none of the usual mechanical compressors do this. In compressors working to considerably higher pressures, the familiar device is employed of performing the total compression in stages, or by two or more successive compressions, with a cooling of the air between each two successive compressions, and it is found well worth while to do this, especially, where considerable quantities of air are handled. Much compressed air service is still on so small a scale as to make the arrangement of debatable value in those cases.

In the compression of air the comparative rates of efficiency seem to lie entirely between perfectly isothermal compression on one side, and perfectly adiabatic compression on the other. In the subsequent use of the compressed air adiabatic and isothermal re-expansion should also be the limits of the range of possible efficiency; but there is here an opportunity for a still lower rate of efficiency by the use of the air without any expansion except after release. It is not worth while to show this in connection with a pressure of 15 pounds; but with a pressure of 6 atmospheres, or say, 75 pounds gage, a common working pressure, it is worth while to note the range of theoretical efficiency. We have to note both the volume of air used and

the M.E.P. developed in its use. With air at 75 pounds gage, following the piston at full pressure for the entire stroke, we have a volume 1 and a M.E.P. of 75 pounds. With air at the same pressure cut-off at .276 of the stroke and expanding adiabatically to atmospheric pressure at the end of the stroke, the M.E.P. should be 35.23 pounds. With the same air cut-off at .1639 of the stroke and, if it were possible, expanding isothermally to atmospheric pressure at the end of the stroke, the M.E.P. would be 26.65 pounds. Here by dead pressure we have 75 pounds M.E.P. per volume 1; with adiabatic expansion we have $1 \div .276 \times 35.23 = 127.39$ pounds per volume 1, and with isothermal expansion we should have $1 \div .1639 \times 26.65 = 162.56$ pounds per volume 1. Isothermal expansion to atmospheric pressure being 1, the standard of perfect efficiency, we have for adiabatic expansion: $127.39 \div 162.56 = .7836$, and for dead pressure without expansion: $75 \div 162.56 = .4613$.

In the compression of air in the usual way, by a reciprocating piston traversing a cylinder, it is of course desirable to have the clearance as small as possible so that as much of the compressed air may be delivered as possible, but the matter of clearance has little bearing upon the efficiency of the compression, as the re-expanding air gives back the power on the return stroke. But in the subsequent use of the air the matter of clearance is one of great importance, as it always involves loss of power. Where the air is used without expansion the filling of the clearance spaces is an absolute and unmitigated loss, and even where the air is properly expanded in use, only a small percentage is recovered from the air in the clearance.

While considerable attention has been given to securing the best economy in the compression of air, and with quite appreciable results, little indeed has been done toward the economical employment of the air after compression, although in the latter there are much greater possibilities of loss, or of saving, involved than in the former.

NICKEL-STEEL RIVETS.

Some very interesting and important experiments were recently made at the works of the Bethlehem Iron Company, South Bethlehem, Pa., by the Engineer of Tests, Mr. Manusel White, for the purpose not only of ascertaining the reliability and comparative efficiency of nickel steel for general riveting, but also to observe the effects of working rivets of this material at different degrees of heat. This latter point is one which was most desirable to have experimental data upon, and the results which Mr. White obtained are such as to remove all doubt as to the possibility of working these rivets safely within perfectly reasonable limits, and with the exercise of only ordinary care.

In preparing for these tests two samples of the steel were taken, from two different heats of different composition. From these samples round bars of $\frac{3}{4}$-inch diameter were rolled, and from the bars were forged a number of $\frac{3}{4}$-inch rivets of standard shape. The rivets of each heat were given a distinguishing mark, No. 1 and No. 2, so that failure of any rivet could be traced to its heat and composition.

In order to establish the effect which different degrees of heating the rivets for driving would have on their strength and reliability in shearing tests, the test pieces were riveted up with the rivets at from obviously different temperatures, and indicated by letters as follows:

A = Bright cherry red.
B = Light red.
C = Yellow.
D = Almost white.

Each test piece was marked both with the letter and figure representing the heat from which the rivet was made and the temperature at which it was driven. In the first lot of test pieces

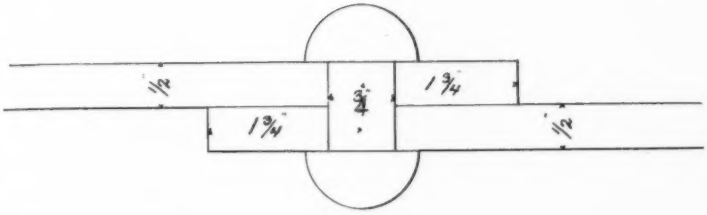


FIG. 1.

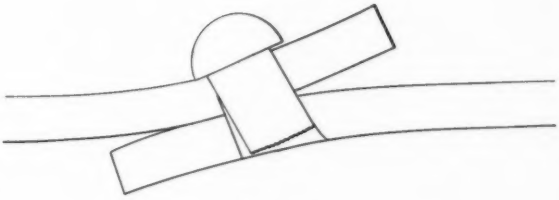


FIG. 2.

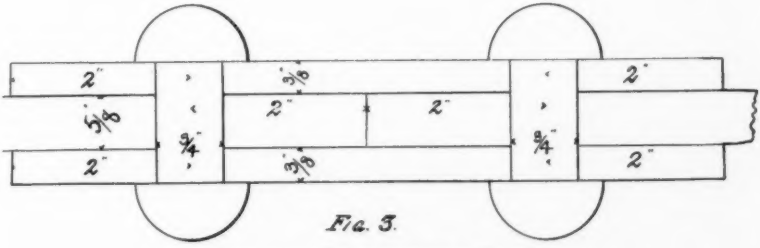
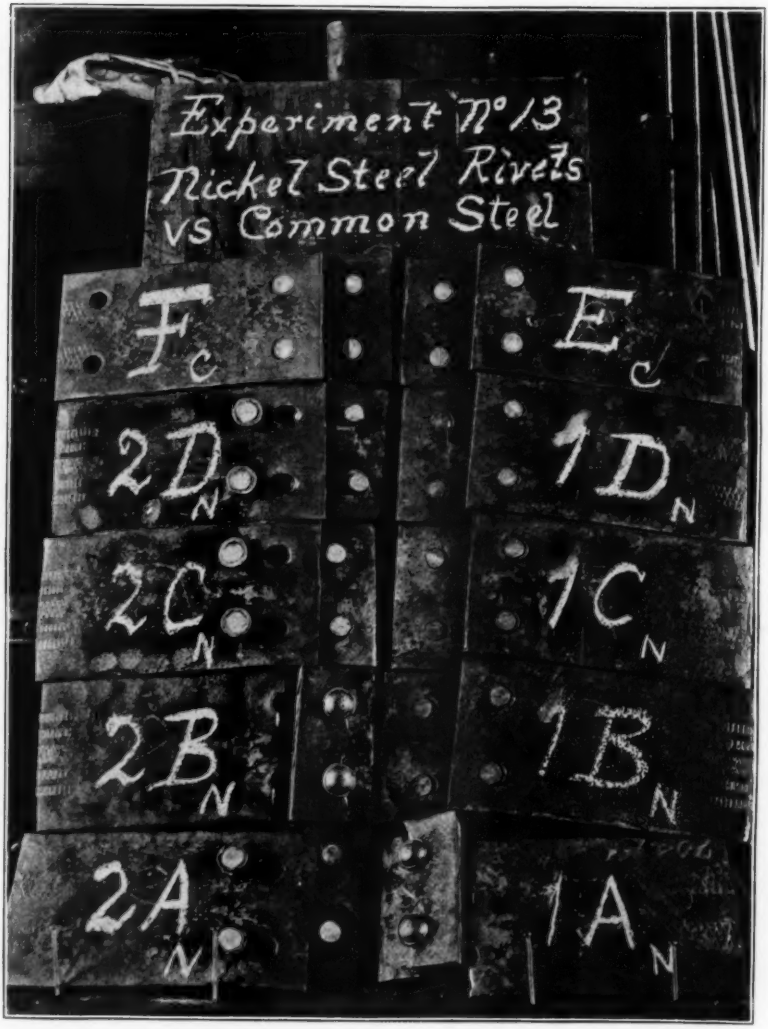


FIG. 3.

ARRANGEMENT OF PLATES FOR TESTS.



NICKEL-STEEL RIVETS. SINGLE-SHEAR TESTS.

the rivets were in single shear as shown in Fig. 1, the plates being $\frac{1}{2}$-inch steel and the center of the holes $1\frac{3}{4}$ inches from the edges of the plates.

The results of this first series of tests were as follows:

¾-INCH NICKEL-STEEL RIVETS—SINGLE SHEAR.

Mark.	Breaking load.	Nature of fracture.	Shearing load per sq. in. in rivets.
1 A	84,800	Plate broke	88,330
1 B	87,600	Rivets sheared	91,240
1 C	80,700	Rivets sheared	84,060
1 D	78,400	Rivets sheared	81,660
2 A	70,600	Heads broke off	73,530
2 B	85,700	Plate broke	89,270
2 C	90,900	Heads broke off	94,680
2 D	79,700	Heads broke off	83,000

A photograph of this series is given here, from which the elongation of the holes in the plate can be seen. To readily understand this illustration it may be pointed out that the upper two test pieces are *iron* rivet tests, alluded to later on, and that the lower four on each side comprise the pieces tabulated above. The broken ends of rivets in 2 A, 2 C and 2 D are laid on the upper plate.

As it was noticed that the plates were excessively bent in the cases of No. 2 rivets where the heads of rivets were broken off, shown in Fig. 2, another series of tests was arranged in which this cause of failure of the rivet would be removed. The plates were arranged as shown in Fig. 3, so as to bring the rivets in double shear, and the same marks were used as before, only in this case the two rivets in the same plate were driven at different heats, in order to trace failure of either to the higher or lower heat. In four joints, A and B heats were used, while in the other four, C and D heats.

The results of this second series, double-shear tests, were as follows:

¾-NICKEL-STEEL RIVETS—DOUBLE SHEAR.

Mark.	Breaking load.	Nature of fracture.	Shearing load per sq. in. on rivet.
1 AB	78,550	Plate sheared	87,200
1 AB	81,600	Rivet broke one side	90,550
1 CD	83,800	Plate sheared	93,100
1 CD	74,050	Rivet sheared	82,270
2 AB	84,200	Plate sheared	93,550
2 AB	82,640	Plate sheared	91,820
2 CD	79,800	Plate sheared	88,660
2 CD	84,100	Plate sheared	93,440

The second photograph shows graphically these results. As in the first photograph, the plate that pulled away or failed is laid over and covers the other plate, for convenience in photographing, so that 2 A B, for instance, is one of the middle plates which pulled out from the rivet farthest from it in the photograph, on the adjoining welt plate.

A study of the illustrations in connection with the tabular data is interesting and profitable.

In order to make some comparison between nickel steel and the ordinary steel rivets two test pieces were made with $\frac{7}{8}$-inch common steel rivets, and were marked E and F. In single shear $\frac{1}{2}$-inch steel plate was used with holes 2 inches from edge of plate. In double shear $\frac{5}{8}$-inch steel plate was used with $\frac{3}{8}$-inch steel plate welts, and the holes 2 inches from the edge. The results were:

⅞-INCH COMMON STEEL RIVETS.

Mark.	Breaking load.	Fracture.	Shearing load per sq. in. on rivets.
E	53,200	Rivets sheared.	43,600 single shear.
F	55,100	Rivets sheared.	46,000 double shear.

From these results Mr. White notes that it may be safely deduced that a $\frac{3}{4}$-inch nickel-steel rivet will replace a $1\frac{1}{16}$-inch, or even possibly a $1\frac{1}{8}$-inch, common steel rivet, thus affecting a saving of considerable plate section and giving increased strength.

NICKEL-STEEL RIVETS. DOUBLE-SHEAR TESTS.

TESTS OF NICKEL-STEEL.

Steel Maker, Carnegie Steel Co. Rolled by Homestead Steel Works.

Kind of material.	Marks.	Chemical analysis.					Original section.		Fractured area.	Elastic limit per square inch original section.	Ultimate strength per square inch of original section.	Elongation, per cent. in 8 inches.	Reduction of area, per cent.	Remarks.
		C.	S.	M.	Nickel.	P.	Diameter.	Area.						
Rods.	1	.23	.017	.61	3.22	.021	.750	.4418	.1772	48,440	82,390	22.5	59.9	Original.
"	2	...	...	...	...	...	.750	.4418	.1698	47,760	79,910	22.5	61.6	Red heat.
"	5	...	...	...	...	...	.750	.4418	.1698	46,400	82,170	22.5	61.6	Bright red.
"	6	...	...	...	...	...	.750	.4418	.1772	55,460	83,980	21.25	59.9	White heat.
"	7	...	...	...	...	...	.750	.4418	.1886	53,880	86,700	17 5	57.3	Bright white heat.
Plate.	1	.28	.025	.52	3.70	.011	1.000	.7854	.3217	...	87,470	19	59.1	Original.
"	2	...	...	...	...	...	1.000	.7854	.3267	48,510	89,260	19.5	58.4	Dark red.
"	3	...	...	...	...	...	1.005	.7933	.3370	48,160	82,950	23 25	57.6	Bright red.
"	4	...	...	...	...	...	1.003	.7901	.3794	49,230	85,940	22.25	52	White heat.
"	5	...	...	...	...	...	1.000	.7854	.5281	49,660	93,070	15.62	32.8	Bright white.
Rods.	1	.23	.017	.61	3.22	.021	.855	.5741	.2165	56,970	81,710	23.75	62.3	Original.
"	2	...	...	...	...	...	.750	.4418	.1590	55,460	81,490	24.5	64	Dark red.
"	2	...	...	...	...	...	.750	.4418	.1626	56,370	82,390	21.75	63.2	" "
"	3	...	...	...	...	...	.750	.4418	.1662	58,410	83,980	23	62.4	Bright red.
"	3	...	...	...	...	...	.752	.4441	.1698	59,010	83,780	22	61.8	" "
"	4	...	...	...	...	...	.750	.4418	.2083	59,760	93,030	16.25	52.9	White heat.
"	4	...	...	...	...	...	.750	.4418	.1924	60,670	91,220	17.75	56.4	" "
"	5	...	...	...	...	...	.750	.4418	.2043	62,700	91,670	15	53.8	Bright white.
"	5	...	...	...	...	...	.730	.4418	.2463	61,580	93,930	17.25	44.3	" "
"	1	...	...	...	...	...	.855	.5741	.2333	57,150	82,920	22.75	59.4	Original.
"	2	...	...	...	...	...	.747	.4383	.1735	64,580	87,610	21.75	60.4	Red heat.
"	2	...	...	...	...	...	.750	.4418	.1772	58,180	84,550	21.87	59.9	" "
"	3	...	...	...	...	...	.750	.4418	.1772	62,930	86,700	22.63	59.9	Bright red heat.
"	3	...	...	...	...	...	.749	.4407	.1735	66,260	86,010	23 75	60.7	" "
"	4	...	...	...	...	...	.749	.4407	.2165	73,080	94,860	16.5	50.9	White heat.
"	4	...	...	...	...	...	.749	.4407	.2043	68,540	92,800	16.5	53.7	" "
"	5	...	...	...	...	...	.749	.4407	.2043	66,950	93,030	16.5	53.7	Bright white heat.
"	5	...	...	...	...	...	.750	.4418	.2003	68,140	91,000	13	54.7	" "

The experiments show that while the maximum strength is not obtained in nickel steel by using too high temperature as a working heat, the higher temperatures here used did not seriously injure the material. It would, of course, be an easy matter to adjust to the proper heat within close limits by exercise of a little care. It was found in heading up the rivets, especially at the lower heats, that more resistance was offered to forming the heads than by common steel rivets. The heads were formed by the sledge and cup set. No heads flew off, as is often the case with ordinary steel rivets, giving additional proof of the superior toughness of nickel steel.

The above summary of Mr. White's report can be supplemented here very appropriately by a table of tests of nickel steel made at Homestead Steel Works. The data is self-explanatory and well worth careful inspection. The field of usefulness of this extraordinary material is rapidly extending and there is no reason why it should not meet the requirements of many parts of machinery to which, as yet, it has not been applied.

COAL ECONOMY OF BATTLE SHIPS ENGAGED IN BLOCKADE DUTY.

By Passed Assistant Engineer Charles A. E. King, U. S. Navy.

The presence of the sister ships *Indiana*, *Massachusetts* and *Oregon*, all first-class battle ships, in the blockading fleet off Santiago de Cuba during the latter part of June and the early part of July, 1898, affords an opportunity to investigate their coal consumption while in this service, and to compare the effect upon coal economy of the different conditions of the fires in their furnaces.

In order that the vessels might maintain their assigned positions in the fleet it was necessary to move their main engines to various signals hour after hour and day after day. The external conditions were identical for each ship, and the kind of coal used practically the same in each case—good bituminous.

Each of these ships has four double-ended cylindrical boilers with a combined grate surface of 552 square feet, and two single-ended cylindrical boilers with a combined grate surface of 64 square feet. The total grate surface in each case is, therefore, 616 square feet. The double-ended boilers are designated by the letters A, B, C and D, and the single-ended boilers by the letters E and F.

For purposes of comparison, the ten days immediately preceding the day of the battle of July 3, 1898, have been selected, and the data of these ten days, from June 23 to July 2, 1898, as given in the steam logs of the ships concerned, have been used in the construction of the table of performances given below.

The best performance is that of the *Oregon*, and shows that moderately heavy, spread fires, continuously maintained under all main boilers, is the most economical condition as regards

coal consumption, in addition to being the ideal arrangement for strategic efficiency.

ON BLOCKADE, SANTIAGO DE CUBA, FROM JUNE 23 TO JULY 2, 1898. (TEN DAYS.)

	Total grate surface. Square feet.	Boilers in use.	Average grate surface in use per day. Square feet.	Fires.	Coal used during period of observation. Tons.	Coal per day of twenty-four hours. Tons.	Coal used per hour per square foot of average grate surface. Pounds.
Indiana.....	616	A, B, C and D for 5 days; A, C and D for 5 days; F for 5 days for "Make up."	447	Medium fires partly banked; no fires in two furnaces of A and one furnace of D.	347.28	34.72	7.21
Massachusetts..	616	B, C and D for 7 days; A, B and C for 3 days.	414	Fires medium, spread all the time.	292.54	29.25	6.5
Oregon.....	616	A, B, C and D for 8¾ days; A, C and D for 1¼ days; B off 1¼ days for repairs.	533	Fires moderately heavy and spread all the time.	249.13	24.91	4.35

MODERN CUPOLA PRACTICE.

By Bertrand S. Summers, Chicago, Ill.

[Read at the Buffalo meeting of the American Institute of Mining Engineers.]

The question is sometimes asked, What is the most important element governing the quality of cast iron for any particular purpose? It would seem that right here lies the basis for the greatest difference of opinion. Some twenty years or more ago silicon was regarded by foundrymen as one of their worst enemies; but since the work of Turner and of Keep silicon has been greatly growing in favor, until one might say that it is regarded in some quarters as the panacea for all evils encountered in the iron foundry. This has led to the founding of a school, the followers of which seem to regard silicon as an all important element, and it would appear, indeed, that in some quarters it is regarded as the one element of decisive importance in pig iron. It is the writer's opinion that graphite is the controlling element in pig iron, and that a greater success is obtained where this metalloid is governed than in cases where the silicon only is watched. We are more or less familiar with the well-known ideas that by gaging silicon the exact mixture suitable for any purpose is obtained; it being only necessary to keep the carbon above a certain unknown minimum, and the silicon being determined crudely by shrinkage and other methods. Indeed, we not infrequently encounter specifications in which the silicon is specified, but no mention is made of either graphitic or total carbon.

SILICON.

This, as nearly every one will agree, is a very important element in foundry practice, its most prominent function being that of promoting the formation of graphitic carbon, while it also

lowers the saturation point of iron for carbon. The former is the property that concerns the foundryman almost exclusively; and it is necessary for him to know about how much silicon cast iron should carry, in order to have the desired properties. Excluding other effects, which will be taken up later, we must always consider what kind of castings are to be made in order to know what content of silicon to strive for in the casting. It seems fair to say that nothing absolute can be stated regarding this question. Frequently we notice in text books and journals that if iron carries this or that percentage of silicon it will have certain properties. This sweeping general proposition the writer cannot accept, being of the opinion that other conditions will affect the content of graphitic carbon as much as, if not more than, the content of silicon. In general, if it is desired to make good machinery castings of close structure, and at the same time so soft that no difficulty will be experienced in tooling them, the silicon should be between 1.50 and 2 per cent., or may even run to 2.25 per cent. It is always wise in these cases to consider the iron used in the mixture. It is well enough to say in a general way that if we have the same chemical composition in cast iron we will have the same properties, but experience has shown that this is true in a general way only. For example, mixtures in which the chief component is charcoal iron show a perceptible difference from those made entirely from coke iron. The reason for this seems to lie in the different conditions of the carbon, which will be mentioned later.

For light hardware, in which great strength is not a very important item, it is well to run the silicon up even as high as 3 per cent. This practice has several advantages. It tends to make the iron more fluid, so that it will take delicate molds well, and avoid difficulty or loss due to shrinkage. It is also said to enable the foundryman to carry more scrap in his mixture. This assertion, however, is open to serious doubt, as the amount of scrap which a mixture will carry is dependent upon the carbon content of the mixture and the scrap.

As silicon approaches or exceeds 3 per cent. the casting becomes more and more brittle, and it is desirable to keep well

within the limit of 3 per cent. in most classes of foundry work. For most foundry purposes, on the other hand, a silicon content below 1.5 per cent. is to be avoided.

As stated above, these rules as to silicon are only true for ordinary foundry mixtures. Special metals, and mixtures containing peculiar irons, are often found to contradict some of the above statements. The figures given, however, are an excellent guide for general practice and will be found applicable in most cases. It will be developed later that there are other influences which affect the iron more than does the content of silicon.

SULPHUR.

The good effects of silicon are frequently counteracted by the presence of sulphur, and mysterious troubles encountered in the foundry are not infrequently traceable to this element; the practical foundryman being, in this respect, usually at the mercy of the pig-iron manufacturer. Most brands of soft iron, both charcoal and coke, are usually considerably below the danger limit in sulphur. Foundrymen, however, are frequently misled by the statement that sulphur need not be considered, as it never occurs in pig irons in sufficient quantities to affect the results of their work. If analyses are made of drillings from castings that give trouble to foundrymen not possessing means for determining sulphur, the trouble will, in many cases, be traceable to this element. In most instances, sulphur is introduced into the mixture through the ferro-silicon irons used to supply the silicon to the charge. The writer has found well-known brands of ferro-silicon containing 0.17 and 0.18 per cent. of sulphur, and in one case 0.34 per cent. If a careful watch is not made of these irons, or if strict specifications are not drawn upon them, it is not infrequent that 0.10 per cent. of sulphur is found. Most furnacemen endeavoring to do so can keep the sulphur below the limit of 0.05 per cent. Not long ago the writer was consulted in regard to some faulty castings, and analyses of them showed 0.12 per cent. of sulphur. The iron was full of small cracks radiating in all directions; but they were not perceptible on the surface, and could only be discovered when the castings were struck

with a hammer. When this was done the casting would fall into many pieces, and the fracture would plainly show that the casting had been previously cracked from one-fourth to one-half of its depth, the remainder of the shell being severed by the blow. Furthermore, the casting showed signs which might have been taken as indicating cold shortness. In all probability the sulphur had been introduced in this case through the ferro-silicon, as the casting carried a considerable content of silicon. A maximum limit of sulphur for good foundry practice should be fixed at 0.10 per cent.; but foundrymen should strive to keep it below 0.08 per cent.

PHOSPHORUS.

This element is present to a greater degree than is commonly supposed in most cast irons. It may be said that for the greater part of foundry work it is an excellent ingredient up to a certain limit. This limit, for most cases, is about 1 per cent. Where great strength and resiliency are desired the phosphorus should be very much below this point. However, in cases of this kind it will seldom be noticeable in high graphitic iron, where it is kept below 0.5 per cent. In snap flask work phosphorus is a very desirable element to the foundrymen, tending to make the metal fluid and to keep it so. Its effect on strength is not immediately discernible if the test bar of cast iron is subjected to a transverse stress. In most cases, if the stress be applied gradually, a high phosphorus iron will register nearly as high as one of lower content. A severe blow upon the bar, however, will soon make apparent the difference in the irons. It is weakness under sudden shock that phosphorus most distinctly promotes; and for this reason it should be kept low where this property would be a detriment. Like sulphur, phosphorus occurs in large quantities in the ferro-silicon irons commonly used in foundry mixtures. It may be stated that most of the common brands of these compounds on the market carry 1 per cent. or more of phosphorus. The writer has known cases in which 7 per cent. silicon iron carried more than 1.60 per cent. of phosphorus. Of course, this is unknown to most foundrymen not having facilities for analyzing their iron; and in this way phosphorus is frequently

introduced into mixtures which never should carry a high percentage of it.

It may be interesting to note here the case of a special semi-steel, mixed by the writer, which carried a trifle more than 0.8 per cent. of phosphorus, graphitic carbon being 1.84 per cent., total carbon 1.97 per cent., and sulphur normal. The bar broke under transverse stress at 3,940 pounds. Another one made from the same mixture broke at 3,910 pounds. The writer has frequently found bars made of this metal which carried over 1 per cent. of phosphorus and broke above 3,000 pounds. In the case of the 3,000-pound bar the resiliency was considerable, the bar possessing spring and showing a considerable deflection before breaking. It would seem from this that phosphorus is not nearly as much to be feared as is commonly supposed.

MANGANESE.

Very little has been said of manganese in its relation to general foundry practice. It is, however, an important element in many ways. It will scarcely be noticed in a mixture up to 0.8 per cent., as far as the ordinary foundryman is concerned. Frequently an excellent casting is found to contain over 1 per cent. of manganese. It is not very long since it was suggested that manganese is a very beneficial element in cast iron, and it has been asserted by some metallurgists that a considerable content of this element is desirable. The writer's experience with manganese in general practice has not been extensive, but it seems to him that this modern view is to be looked upon with favor. Although it is well known that manganese promotes combined carbon, silicon predominating in the iron would tend to counteract this effect. Manganese, however, has considerable effect on the magnetic properties of the iron, which has been discussed in another paper by the author ("Journal of the Society of Chemical Industry"), December, 1897.

It is well known that manganese possesses the property of preventing sponginess of the metal, or blow holes, by reacting with the occluded gases of the metal; and it seems that the modern view is going to work considerable advance in this way.

If the foundryman should be able to run sufficient manganese into his mixture, without hardening the metal, to rid the iron of blow holes or prevent sponginess, manganese will soon be in high favor for general foundry practice. There is reason to believe that this will come to pass at no very distant date. Since the publication of the above-mentioned article of the writer, later studies of the effect of manganese upon the magnetic properties of iron have adduced striking arguments, tending to substantiate the ideas advanced by R. A. Hadfield, as to the probable existence of a carbide of manganese, which exerts considerable influence on the properties of steel. It would seem, however, that in high carbon irons, particularly in those carrying a considerable proportion of graphite, this effect is somewhat hidden. It is more noticeable as the content of graphitic carbon decreases.

CARBON.

The consensus of opinion seems to be that a great deal is yet to be discovered relative to carbon. Anomalies have frequently been encountered in foundry practice which seemed to indicate strongly that a clearer knowledge of the state of the carbon would greatly aid matters. There is no question that graphitic carbon is the softening agent in cast iron; and, so far as silicon can control this, it is the governing agent. The writer hopes to show, however, that in many cases silicon is powerless to effect this change in the state of the carbon. It is doubtful whether the form of carbon usually called graphite is always composed of the same variety of carbon. It will be remembered that some five or six years ago, Professor Ledebur, in an excellent paper on carbon in iron, described four states of this metalloid. The carbon in a transition state toward graphite (as we may describe it) he termed graphitic temper carbon. He also stated that there was no known method of determining this form, and that it was always estimated with the graphite. It is open to question then if, in many cases where we determine graphite, some of it does not represent graphitic temper carbon.

To digress a trifle, mention may be made here of an old dispute between the practical man and the technologist as to the value

of the fracture in determining the quality of pig iron. Probably most technologists will agree that, as a general indication, this practical method is very useful, but very misleading. Some time ago the writer had an excellent opportunity to observe this. A very open-grained iron was found to contain much less graphite than an iron possessing a fracture of inferior appearance.

S. H. Chauvenet has given some interesting figures, showing that a lower bed fed from the blast furnace is normally always close grained, though it gives practically the same analysis as the rest of the cast; and he shows, further, how obstructions in the tap hole which cause intermediate beds to fill up slowly will make those beds close grained, while if the lower bed be filled rapidly it will show an open grain. Finally, if we compare a charcoal iron with a coke iron, it is a well-known fact that although the charcoal iron may carry a very much higher percentage of graphitic carbon, it shows a closer and denser fracture, while the coke iron has a very open fracture, the graphite occurring in nests, as it were, and falling to the ground in flakes when the iron is handled. A possible explanation of this might be that the graphite commonly determined in charcoal iron represents relatively larger proportions of graphitic temper carbon, while the coke iron carries a very much smaller percentage. The iron, assimilating the graphitic temper carbon, makes a close and homogeneous metal, while the graphite tends to open the grain and segregate, thus frequently causing sponginess in the metal. This would seem to explain the reason why charcoal iron makes a denser and more uniform metal when introduced into foundry mixtures, and hence is generally preferable to coke irons. This suggestion is offered tentatively; the writer not being able, as yet, to identify the temper carbon in such irons.

It may not be amiss, in this connection, to cite an incident in the use of the semi-steel mentioned above. This metal possesses a magnetic permeability midway between cast iron and cast steel, being a gain of about 50 per cent. over cast iron. A test bar from a machine, which had showed inferior results, proved the metal to have the same permeability as cast iron. This being unex-

plained, an analysis was made of the bar, with surprising results. The analysis was almost identical with that of a bar which had showed superior results in this direction. The graphitic and total carbon were practically identical. The mixtures were entirely the same, and the metals had been worked in the foundry in the same way, with the exception that different blast pressure had been used. The bar showing the lower results was very open and showed a dark-grained fracture. The bar giving higher results presented a characteristic silvery appearance and was soft and tough. It was exceedingly dense and turned more like steel, while the former bar turned just as cast iron would do. The micro-photographs of these two bars showed radical differences, and seemed to confirm the view that these were due to temper carbon. Further, this metal, when properly made, is homogeneous throughout the casting, and the graphitic carbon shows no tendency to segregate. It would seem from this that the state of the carbon was the governing factor; and cases such as this have prompted the above suggestion.

In this laboratory an attempt was made to oxidize the temper carbon by prolonged treatment with fuming nitric acid under high temperature, but without avail. This is in accord with previous work along this line. Hopes are entertained that investigations now in progress will yield some method by which temper carbon may be identified and estimated in these irons.

COMBINED CARBON.

It is usually admitted that combined carbon embraces more than one kind of carbon. This is, to some extent, substantiated by work upon the magnetic permeability of metals relatively high in carbon. However, the present state of the art will not permit much to be said with certainty in this direction. Reference may be made in this connection to recent work of Messrs. Donath and Haissig on silicon irons, in which they cite the fact that a high silicon iron, when analyzed for carbon by ordinary methods, gives about 1.36 per cent. less of carbon than when the drillings are oxidized completely by combustion with lead chromate, or volatilization in chlorine. Lower results were also obtained when

the metal was oxidized with chromic and sulphuric acid. This difference, Messrs. Donath and Haissig suggest, is due to some silico-carbide. The writer has endeavored to duplicate these results, working on a ferro-silicon containing about 7.5 per cent. of silicon. The total carbon, obtained by solution in a double chloride and the residue burned in a combustion furnace, was 2.24 per cent. In every case in which the carbon was determined either by direct combustion with lead chromate, or the residue from the chlorine treatment burned in a combustion furnace, the results agreed quite closely with those obtained by solution in a double chloride. It is possible, however, that the results obtained by these scientists may be true for ferro-silicon higher in silicon; or it may be that the metal used for their experiments was in some respect anomalous.

RELATION OF SILICON TO GRAPHITE.

Having discussed these general relations, let us now endeavor to see what grounds there are for the assumption that silicon is the governing factor in cast iron. If we have several pieces of cast iron, made at different dates from practically the same mixture, the analyses of which show practically the same total carbon and a variation in silicon, we have an excellent opportunity to trace the effect of silicon. For example, in the following table are irons which would seem to show this quite clearly:

TABLE I.—ANALYSES OF CHARCOAL IRON CASTINGS.

	I.	II.	III.	IV.
Silicon	2.20	2.66	2.92	2.41
Graphitic carbon	2.92	2.93	2.77	2.98
Total carbon	3.44	3.48	3.41	3.42

The other constituents of these irons are nearly the same, and all of them are controlled as far as possible in foundry practice. They were made from almost identical mixtures, as is clearly indicated by the uniformity of total carbon. It is evident that this table does not support the unqualified assertion that an increase in silicon causes a proportional increase in graphite, and the practical rule, based on that theory, that silicon may be blindly added to the foundry mixture, without considering other

conditions, in order to increase graphite and soften the iron, is not substantiated. Comparing irons I and III, we find that although the latter contains 0.72 per cent. more of silicon than the former, the graphite is 0.15 per cent. lower, while the total carbon is practically the same. Obviously this increase in silicon has not produced graphite, yet the total carbon indicates that there was no marked difference in burden.

Taking IV as the second in the series, we see that silicon increases by about 0.20 per cent., yet that the graphite is nearly constant, except as to III, which is both highest in silicon and lowest in graphite. The fair deduction seems to be either that silicon has no marked effect upon graphite in ordinary foundry practice, or that there are other conditions more potent. The latter view seems the more probable.

The above analyses are taken from a vast number made in the course of practice, which confirm this conclusion. Daily records for months show conclusively that the silicon varying between 2 and 3 per cent. has not nearly the effect on the graphite that it is usually supposed to produce. No relation apparently exists between the change of silicon and the content of graphite within these limits, and there is little if any doubt, if we can judge from this long series of tests, that there are other influences in cupola practice which are more potent than the variation in silicon. The above table has been selected as most clearly setting forth this view.

Another proof of this proposition is seen in the analyses of pig irons, before they are introduced into the cupola. Pig iron shows the effects of the metalloids in the blast furnace, instead of in the cupola; yet even in the blast furnace, with its high temperature, the silicon is not always able to govern the graphite. For example, the following are strong indications in this direction:

TABLE II.—ANALYSES OF PIG IRONS.

	I.	II.	III.	IV.
Silicon	7.94	7.43	3.36	3.30
Sulphur	0.041	0.029	0.051	...
Phosphorus	1.39	1.05	0.606	...
Graphitic carbon	2.02	1.95	3.31	3.26
Total carbon	2.24	2.19	3.33	3.37

Here it appears that the irons carrying more than 7 per cent. of silicon have less graphite in proportion to the total carbon than the one containing 3.36 per cent. Number III, however, is a remarkable iron, and one that is seldom seen, although its high proportion of graphite to total carbon is quite characteristic of the brand, and has been found in most shipments received from this furnace. This anomaly must, therefore be due to local conditions.

The castings in Table I were all compounded from high graphitic charcoal iron. In coke-iron mixtures the failure of silicon to increase the percentage of graphite is even more marked. The following analyses are taken from casts made entirely from coke irons:

TABLE III.—ANALYSES OF COKE-IRON CASTINGS.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Silicon.....	2.85	3.76	2.62	2.47	3.18	3.11	2.79	2.95
Sulphur.....	0.073	0.083	0.074	...	...	...	...	...
Phosphorus.....	0.557	0.612	0.469	...	...	...	...	...
Manganese.....	0.39	0.260	0.42	...	...	...	...	...
Graphitic carbon..	3.13	3.05	3.17	2.55	2.69	2.78	2.67	2.61
Combined carbon.	0.18	0.24	0.08	0.74	0.51	0.62	0.54	0.60
Total carbon.....	3.31	3.29	3.25	3.29	3.20	3.20	3.21	3.21

The first four members of this table have about the same total carbon, and were made from the same irons, with but minor changes in the burdening. It is readily discernible from these irons that little if any relationship can be traced between the silicon and the graphitic carbon. Looking at the last four members, the total carbon contents are seen to be practically identical, while the graphitic carbon is very nearly the same in the irons containing the highest and the lowest content of silicon; and, again, no relation can be traced between silicon and graphitic carbon. As in the case of the first four, these mixtures were compounded from the same irons with but minor changes in the burdening.

That temperature controls the effect of silicon is shown when a close examination is made of different shipments of the same brand of pig iron, the blast furnace running on the same ore mix-

ture. A case came under my personal observation recently, in which the graphitic carbon ran from 3.40 to 3.50 per cent., the silicon remaining in the neighborhood of 1.5 per cent.; but when the silicon rose to 1.8 or 2 per cent. the graphitic carbon rose above 3.50 per cent. In nearly every case of this kind a decrease in the total carbon was likewise noticed. This has also been frequently noticed with other brands of iron, and it is more apparent with charcoal irons than with coke. The heat in the blast furnace seems to be great enough to make the silicon a more important factor.

It is hardly legitimate to attribute these differences to the effect of the other elements, as a glance at the tables will show that they do not vary enough to enter into the consideration. It would seem, on careful consideration, that the effect of silicon is largely governed by the temperature at which it is allowed to act. It is doubtful if the necessary temperature is obtained in the cupola to permit the silicon to have a very strong effect upon the carbon, where its content does not vary beyond certain limits. It also seems probable that, where the burden is light, the effect is not as marked as in the case of large burdens, where more heat is developed.

INFLUENCE OF COKE RATIO.

Frequently one hears among foundrymen that this or that one uses certain fuel ratios, but it is seldom stated under what conditions the melt is made. One foundryman is melting iron with a ratio of one to thirteen, while his neighbor is running on a ratio of one to seven. This means almost nothing, unless the amount of iron melted and the condition of the material introduced into the cupola are taken into consideration. It need scarcely be said that the foundryman who melts 60 tons per day can make a better showing in relation to fuel consumption than one who melts 5 tons and has the same iron poured from his cupola. The foundryman having a smaller burden uses more coke on his bed in proportion to the iron melted. It is also evident that, where it is desired to melt large pigs and large-sized scrap, a greater coke consumption is necessary to tap the

same iron from the cupola. Barring these two conditions, which are evident to every one, the iron is, within certain limits, softer when more coke is used. If analysis is made of metals cast with different coke consumption and practically the same burden as a general rule, the one melted with the higher coke consumption, up to a certain limit, will contain the most graphite. This is only true when the cupola is run on a coke consumption below what is really necessary to pour iron of a high temperature, and this, again, is largely dependent upon the blast; but where little attention is devoted to the blast, and especially where the blast pressure is below what it really should be, an increased coke burden will often have a beneficial effect upon irons, if too much is not added. If a foundryman is using his blast judiciously and the coke ratio is figured for the best economy, little can be gained from an increased coke consumption.

INFLUENCE OF OXIDIZED MATERIAL, ESPECIALLY RUSTY SCRAP, UPON MIXTURES

Little attention has been paid to the peculiar effect of introducing rusty material into the cupola. Only one experience of this kind is necessary to convince a foundryman of the deleterious effect of corroded scrap. The surface rust on pig iron is usually not noticeable, but where corrosion has taken place to any considerable depth a very bad effect is quickly discovered. This is particularly true where light scrap is used, and a large surface has been exposed to the corrosive effect of the atmosphere, in proportion to the small volume. A prominent effect in bad cases of this kind is to make the iron exceedingly dirty and spongy, and when this dirt is noticeable, the cleaner the material introduced into the cupola the cleaner will be the casting obtained. The writer was confronted some time ago with a serious complaint of dirt in the iron, and on investigating the case found it due entirely to light scrap which had been seriously corroded. Upon the dropping of this scrap from the mixture the trouble entirely disappeared. There is very little doubt that, in many cases, spongy iron poured from the cupola is trace-

able to the use of corroded material. Besides this inconvenience, material of this nature tends to harden the iron to a limited extent. But this is not nearly as noticeable as the former effect, and cannot be detected in iron high in graphitic carbon.

EFFECT OF THE BLAST.

There is scarcely any one factor in cupola practice deserving of more close and constant attention than the blast. There are reasons to believe it exerts considerable influence in furthering the mutual reactions of the different elements in the metal, but this has not been clearly demonstrated in the tests thus far made. Aside from its effect in this way, increase of blast seems to have a decided tendency to increase the total carbon in the cast iron and correspondingly to increase the percentage of graphite. As demonstration of this, the composition of the irons in the following table, which were made from the same mixture at different dates, may be interesting:

TABLE IV.—ANALYSES OF CASTINGS FROM THE SAME MIXTURE.

	I.	II.	III.	IV.	V.	VI.	VII.
Silicon	2.30	2.74	2.03	2.27	2.04	2.10	2.21
Graphitic carbon	2.98	2.59	2.98	3.07	2.90	3.11	3.06
Total carbon	3.44	3.15	3.67	3.52	3.61	3.74	3.63
Pounds of iron per pound of coke,	6.4	5.4	6.2	6.3	7.6	7.6	7.0

The first three members of this series were cast from a larger cupola than the remaining members. Only the third iron shows a high carbon content that compares with the last three. The blast apparently varies. Iron is sometimes poured which can only be accounted for in this way. If II is contrasted with I and III a decided difference is noticed; also III differs considerably from I and II. These irons are all made from practically the same mixture, and are here mentioned to show the anomalies that are so common in foundry practice. Unfortunately, reliable measurements have not been secured on blast pressure, but, inasmuch as the air is supplied by an open blower, the amount of air passed through the cupola would be largely dependent upon the resistance found in the cupola itself. The

true criterion of the effect of the blast is the amount of air passed through the cupola in a given time, and not the blast pressure. Whenever an attempt was made to measure the blast pressure it was always found to be practically the same, even when both cupolas were run at once. The explanation of this is obvious. Inasmuch as the fan is not entirely enclosed, the pressure can never exceed a certain maximum, or air will be forced back through the fan. In the case here cited the fan was somewhat overworked, and probably air was being forced back through it. It would thus happen that, if the burden offered more resistance at one time than at another, less air would pass through the cupola at that time. This would seem to be the explanation of the difference in these three irons made from the same cupola.

This hypothesis is apparently verified when the remaining four members of this series are considered. These four irons are compounded from the same pig irons as the first three, as are also all the irons in Table I. The mixture has been varied but slightly, and if any difference could be expected from this cause the irons in Table I should show higher carbon contents than those of Table IV. The last four irons of Table IV were melted in the same cupola as those of Table I, but more air was passed through the cupola in the former case. Also more air was passed the cupola in melting the last three members of Table IV than in melting No. IV of this table. This was accomplished by using more tuyere openings. In the case of iron IV two openings in the upper set of tuyeres were used, besides the full lower set. But with the last three irons of this series the full upper, with the full lower set, was used. With the irons of Table I only the lower set was used. Contrasting iron IV with those of Table I, a higher content of total carbon is noticed, and also a corresponding rise in the graphitic carbon. Again, comparing members V, VI and VII with IV, the same thing is noticed. This is particularly noticeable in VI, and is probably due to the causes mentioned above.

These tables do not appear to demonstrate that silicon has had any greater effect in promoting graphite under the effect of

the increased blast. It may be that if the blast pressure were increased to a still greater extent an effect would be noticeable. It would seem almost a demonstrated fact that the temperature is the governing factor of the effect of silicon, and the temperature of the cupola is certainly increased by increased blast, if a certain maximum be not exceeded. This limit is seldom reached in foundry practice, and faulty iron is more frequently due to a scarcity of air than to an excess. The blast is probably one of the most important factors in foundry practice, and many of the mysteries not yet explained may be traced to its door. There is scarcely any doubt that it has a marked effect upon the content of total carbon, and it is not unlikely that when the results of further investigation are known the amount of air passed through the cupola will be found to condition, to a certain extent, the effect of the metalloids in the iron.

IRON MIXTURES AND IRON SPECIFICATIONS.

An attempt has been made in the foregoing to demonstrate that the desire for silicon has been carried to an extreme. This desire has become a mania in some quarters. If the foregoing tables prove anything, they certainly prove that high silicon irons are, in many cases, a useless luxury. A certain amount of silicon is undoubtedly necessary, but the plan of gaging the value of irons by their content of silicon is but one step in advance of the old fracture method. The carbon is undoubtedly the governing factor in irons, and the most radical advocate of silicon can do nothing with foundry mixtures without a certain carbon content. It seems, then, that total carbon is one of the most important elements to specify in purchasing foundry irons. The writer has yet to meet with an iron too high in carbon to be of excellent use in the foundry. It has been the custom in our practice to specify 3.75 per cent. of total carbon in our No. 1 iron, especially when charcoal irons are purchased, while a very lenient specification is allowed in silicon, it being, for charcoal iron, not below 1.50 per cent. The furnaceman is allowed to have silicon about anywhere he wants it as long as he can furnish iron with the necessary carbon. A minimum graphite specification is also in-

serted in nearly every case. The philosophy of this is obvious from the foregoing. In the cupola comparatively little combined carbon is changed to grapite, and this is especially true when the heats are small and, consequently, the heat developed is not sufficient to produce any marked change in this direction. This fact can easily be demonstrated in practical work, where frequent analyses are made of daily casts, and the compositions of the irons composing the mixture are known.

In these specifications the minimum is specified, and any variation must be above this limit. This is thoroughly practical, and has been in operation long enough commercially to demonstrate its value. It is difficult to get iron merchants to make carbon determinations, but they will agree to furnish iron under specifications requiring certain minimum limits of total carbon and graphite. Whether the latter is specified or not, there can be no doubt about the necessity of specifying total carbon. Very little attention is paid to silicon in the work, as most of the high carbon irons will carry sufficient silicon for most classes of work. However, it is often useful to require a certain silicon content in the iron, so as to get sufficient graphite, as the heat of the blast furnace is sufficient to enable the silicon to control the graphite to a great extent. In the best snap-flask work, where a large proportion of charcoal iron is used in the mixture, 2 per cent. of silicon is found to make elegant castings, and in such mixtures no ferro-silicons are used; but a high silicon coke iron, carrying over 3 per cent. of silicon and about the same of graphitic carbon, is used. This gives good results, especially where a high grade of machinery castings and fine snap-flask work are poured from the same mixture. This is further substantiated by analyzing some of the best castings of tools and machines that can be found on the market. Some of the best known firms making this class of work will be found to be using this variety of iron. With coke iron it is well to run the silicon a little higher, although for machinery work it is best not to have it too high.

When trouble is experienced with open or spongy iron, and the trouble cannot be traced to some such cause as rusty scrap, a good procedure is to run the total carbon in the casting as

high as possible. This will give a higher content of combined casbon, and at the same time the high content of total carbon, while the graphite, usually increased slightly in this way, will keep the iron soft. When this is done it is well to consider the content of silicon, and if this is much over 2 per cent. a decrease will be found beneficial.

THE USE OF CARBON.

As mentioned in the first portion of this paper, silicon is commonly believed to enable a mixture to carry more scrap. This belief is open to serious doubt. It is obvious that if a mixture is running low in carbon, and ferro-silicon is added in greater amounts to enable the mixture to carry more scrap, this procedure will not only fail to enrich the carbon content, but will actually impoverish it. The reason for this lies in the fact that high silicon iron carries less graphitic and total carbon than a good scrap and much less than a good cast iron. For this reason it is evident that when ferro-silicon is added to the burden it is certain to lower the content of carbon in the cast iron somewhat. Inasmuch as the iron is dependent upon carbon for its softness, it is open to grave doubt whether, by increasing the silicon, and thereby decreasing the carbon, by adding ferro-silicon, any more scrap can be carried and the same quality of iron poured from the cupola. The amount of scrap that can be loaded into the cupola without changing the quality of the iron is dependent upon the carbon, and especially upon the graphite. Even if we admit that an increase of silicon can cause an increase of graphite, yet if there is not sufficient carbon present to be changed into graphite, the graphitic carbon cannot be obtained in the required proportion. Further, when it is doubtful that silicon will cause any appreciable increment in the graphite, it is open to question if the ferro-silicon does not tend to lower the scrap-carrying ability of the mixture.

A high carbon mixture averaging, for example, 3.10 per cent. graphite, and about 2 per cent. silicon, will carry considerably more scrap than a mixture containing over 3 per cent. silicon and lower in graphitic carbon, or than a mixture impoverished

in total carbon, no matter what the silicon content. This assertion can be proved in practical work, and it would seem that the popular idea to the contrary is based on a fallacy.

The carbon determinations in the foregoing tables were all made by the oxygen combustion method, and the greatest care was exercised to insure accuracy. The determinations have been checked, and the results from the furnaces used, checked with results from other laboratories. In this connection, thanks are due to E. J. Ericson, whose excellent work in this particular has greatly aided this investigation.

In conclusion, it should be mentioned again that the fan supplying the air to both of the cupolas employed in this investigation was somewhat overloaded. Therefore it is possible that foundries supplied with better blast facilities will obtain results different from the above; that a greater effect of the silicon will be noted and perhaps a greater benefit traced to the use of ferrosilicons. If this should be so it would only go to demonstrate the effect of the blast in foundry practice.

SMOKE PREVENTION.

By W. H. Booth.

At the present writing there has been for some time a strike in progress in the South Wales coal industry. It is from South Wales that comes the "smokeless Welsh" coal that is so much used in London, regardless of its cost, by those who cannot master the firing of bituminous coal or who have been so unfortunate as to have been loaded up with steam boilers put in by engineers who either did not know or did not care anything about the probable future of the work. For some time past Welsh coal has been practically absent from the market for the above-given reason, and many steam boiler owners have been hauled up before sundry magistrates to show cause why they should not abate the smoke nuisance they are making. These prosecutions take place under a certain law known as the smoke prevention act. A good deal of latitude is allowed under this act in cases where smoke cannot be entirely prevented, and steam users have been claiming in defense that, as their furnaces are constructed for Welsh coal, it is impossible for them to burn bituminous fuel without smoke until the furnaces are altered, and in some cases orders have been made upon them to reconstruct these furnaces to burn bituminous fuel. In one case, time to the extent of several months has been given to do this, and no doubt before this is done there will be plenty of Welsh coal, and the change will be put off and put off, until the periodic Welsh strike will come again, and we shall then see how these same steam users will answer the next prosecution for smoke with the present orders to reconstruct, unfulfilled.

Seeing that Welsh coal is so very much dearer than bituminous coal in London, in spite of the arguments of some engineers, who harp on the old string that the best fuel is the cheapest in the

end, which they appear to do as a cover to their inability to use bituminous fuel, it is a little surprising that more effort is not made to burn the bituminous coal, especially as it can be burned without smoke under proper conditions.

When burning bituminous fuel smoke is sure to be made whenever the gases from the fuel on the grate rise directly upward among the tubes. This is the way the gases do escape in the ordinary construction of the majority of water-tube boilers. In consequence, these boilers are sure to smoke badly with bituminous coal, and cannot be cured unless their furnaces are put into the shape of the ordinary furnace of a Scotch or other horizontal boiler, fired internally or externally. In these boilers the whole of the products of the furnace travel together over the fire and toward the bridge and become considerably intermingled. If, when so mixed, the mixture contains the requisite amount of air, the whole of the gases will be completely consumed, provided they are still at a temperature sufficiently high to enable combustion to proceed. This is where one difficulty arises. If too much air be admitted this alone might cause smoke by excessive cooling, but the chief cause of cooling is obviously the comparatively cold plates of the boiler itself. If 1,000 or 1,500 degrees is a proper temperature for the gases, it is easy to see that a boiler plate at 350 degrees is a very chilly object indeed, and it is small wonder that freshly distilled gas from long flaming coal is cooled below the ignition point.

In Lancashire boilers there are frequently water pipes placed across the internal tube beyond the bridge. So far as my experience goes, these are of little or no value as strength givers, and they are very effective in extinguishing nascent flames. When all these things are considered it is forced upon one's attention that to burn bituminous coal without smoke we must thoroughly mingle the gases with the correct amount of air and must prevent the mixture being too rapidly cooled. This latter can be effected by protecting the cold plates of the boiler by firebricks. It is because the sides of the furnace of the externally-fired boiler are of firebrick that these can be made to give out less smoke than internally-fired boilers of the Scotch type,

in which usually the fire is cooled by a water arch all over the furnace area. The ordinary arrangement of the water-tube boiler is, however, about as bad as it can be designed to be. In fact, such boilers are only fit for coke and other smokeless fuels, as no attempt is made at gas and air mixture, but the gases are hurried straight up from the grate to the cold tubes and forthwith extinguished never to relight.

But there is an addition made to some water-tube boilers in the shape of an extra row of water tubes below the ordinary sets, and these tubes carry a roof of firebrick, so that the sides of the furnace and a portion of the roof are of firebrick, and this roof compels the products of combustion to travel to a point some distance along the furnace at which combustion may proceed. The chamber above this firebrick roof is also roofed in by a set of firebrick tiles supported on the lowest row of ordinary tubes, and thus there is good prospect of securing smokeless combustion.

One thing more is needful—the correct amount and application of a secondary air supply above the fire. This is usually supplied above the door and often in a solid stream. This position is correct, but the manner is incorrect. The air ought to be supplied in a multitude of small jets directed toward the fire over its area so as to facilitate the mixture with the furnace gas. Thus mixed and kept hot the gases burn at the bridge, and continue to burn if provided with a sufficient space in which to complete their combustion. There is danger of using too much air. Chemically, the total air required in a furnace is twelve times the weight of the coal. The secondary air above the furnace is apt to be admitted too freely. Its admission should cease gradually after each fresh charge of fuel is coked off or it will produce waste. Hence the use of automatic devices to cut off the air supply at the proper time. It is desirable to have this secondary air admission made positive by means of a fan, in order that air may be blown in while firing is in progress, when the chimney damper is nearly closed and the under-grate supply of air should be diminished, pending the closing of the door. But in

shutting off the secondary air supply it seems likely that the best results would be got by shutting it off a section at once, instead of by gradually closing the admission valve for the whole. Thus if there be three perforated air-jet pipes it would seem better to close them one by one, in order that those still open should spurt with their maximum pressure, than to gradually close three together and render the jets of air sluggish.

If the foregoing precautions fail to prevent smoke, side firing may be also tried. It involves no more labor than ordinary whole-surface firing. Side firing of a furnace measuring 6 feet long by 4 feet wide may perhaps be best carried out by firing upon alternate corners. Thus at one time fire the left front and the right back corners over an area each 3 by 2 feet, and at the next firing cover the other rectangles. This will tend to more even admixture at the bridge, and enables a simpler air admission to be contrived, though as a rule much attention is not given to this item. Recently I found air being admitted through a plain opening measuring 18 by 6 inches, an opening probably much too large in area and also admitting air unbroken and in a bad condition for mixing with the gases. Smoke, it is true, was being prevented, but probably at a considerable expense in the shape of excessive air and reduced evaporation per pound of fuel. It is well known that black smoke represents comparatively little in the shape of solid carbon, and that the prevention of smoke cannot be effected with any certainty of economy of fuel. This is because it pays better to use nearer the correct chemical amount of air and produce some soot, because of more or less imperfect mixture, than to pour in a larger excess of air and completely prevent smoke. This points to the great importance of minimizing the secondary air by introducing it as finely divided as possible. Clearly, with a sufficiently long refractory furnace tube, thorough admixture of the air would be effected and every particle of gas would be satisfied with its molecule of oxygen. But practical considerations limit furnace dimensions, and it is practically impossible to reduce air supply to its chemical minimum. With a chimney draft, attempts at proper admixture often defeat themselves by paralyzing the draft. Herein

comes the advantage of mechanical draft, which can be made to fit any conditions we are likely to impose.

It is thus seen that the combustion of bituminous fuel is a compound operation; the solid carbon burns on the grate by means of air admitted below the grate, and the volatile hydrocarbons burn above the fire by means of air admitted also above the fire. In each case the air requires admission in fine streams. This compound operation demands the draft to be varied to suit the fuel, and with chimney draft it is often the practice to have light dampers to the ash pit so as to regulate the air admitted below the grate. This can be effected by means of the usual blast gates where the forced draft is employed. We have thus a considerable control over the rate of combustion of the solid fuel on the grate, but we have not much control, if any, over the rate of combustion of the hydrocarbon evolved from the green fuel. This fuel is thrown upon the fire, its hydrogenous gases are evolved quickly, and we must supply them with air or smoke will be made. As a rule, if fairly well arranged as regards fine division, the loss due to smoke prevention arises from the air supply being too long left on, and an automatic closing device is required to prevent this.

An advantage of externally-fired boilers so much employed in America is that a steeply-sloping stepped grate may be used under them and fed by some mechanical means on the coking system, and the fuel may be made to travel sufficiently quickly down the slope to prevent an excessive flow of air coming through the grate. This cannot be done with English boilers, which are usually fired internally, and the problem of economical mechanical stoking is very much more difficult here than in America, for a fire cannot be made to travel and pack close upon a horizontal grate, no matter how the bars lift and creep. With gravity to aid this can be done, and if anything brings about the use of water-tube boilers here, probably this question of mechanical stoking will have as much as anything else to do with it.—"American Machinist."

THE INFLUENCE OF BISMUTH ON BRASS AND ITS RELATION TO FIRE-CRACKS.

By Erwin S. Sperry, Bridgeport, Conn.

[Paper for American Institute of Mining Engineers.]

It is a tradition in the brass industry that bismuth is an injurious element in brass, even more deleterious than antimony; but such a belief has lacked verification. The occasional presence of bismuth in commercial copper (although less frequent than was formerly supposed) led the author to investigate this tradition.

The following experiments were conducted in the same manner as those described in a previous paper on "The Influence of Antimony on Brass," to which the reader is referred for details. The purest Lake Superior copper was used, and after it had been melted the bismuth was introduced as an alloy of copper and bismuth. Zinc in the form of pure refined metal was next added, and the mixture was stirred and poured into an iron mould $\frac{5}{8} \times 2\frac{3}{8} \times 24$ inches. All rolling was performed cold. For reasons previously mentioned, a base alloy was used, consisting of copper, 60 per cent., and zinc, 40 per cent.

Experiment No. 1.—Copper, 59.50; zinc, 40; bismuth, 0.50 per cent. Melted 5.5 pounds of copper, added 0.5 pound of an alloy of copper, 90, and bismuth, 10 per cent., and then 4 pounds of zinc. Rolled from 0.595 to 0.472 inch, a reduction of 20 per cent. Cracked badly on one edge, but otherwise the surface appeared unchanged. Annealed, and the plate fire-cracked on both sides. While many of the cracks were merely superficial, others penetrated the metal so deeply that further rolling became impossible. While this alloy is cold-short, it is less so than the corresponding antimony alloy. The fracture was finely crystalline.

Experiment No. 2.—Copper, 59.69; zinc, 40.06; bismuth, 0.25 per cent. Melted 5 pounds 6 ounces of copper, added 3.75 ounces of an alloy of copper, 90, and bismuth, 10 per cent., and then 3.75 pounds of zinc. Rolled from 0.655 to 0.495 inch, a reduction of 24 per cent. Cracked slightly on the edges, and a few checks appeared on the surface. Annealed, and fire-cracks formed on both sides of the plate. These cracks were quite numerous, but did not penetrate the metal as deeply as those in Experiment No. 1. Rolled from 0.495 to 0.416 inch, a reduction of 15 per cent., and the fire-cracks became greatly enlarged; many others also appeared. The latter were apparently *latent* fire-cracks, as the plate did not show any additional cracks on the edges. Such latent fire-cracks were noticed in succeeding experiments, and are evidently due to the presence of bismuth, as the reduction in rolling was not sufficient to cause them. Rolled still further to 0.355 inch, a reduction of 29 per cent., and the plate cracked to pieces. The edge-cracks first formed did not increase in size perceptibly.

The following test was made on a rod (not annealed after being turned) cut from an ingot which was cast at the same time as the plate. The results show that the cause of the cracks was not insufficient elongation.

Length, 12 inches; diameter, 0.270 inch; sectional area, 0.0572 square inch; breaking strain, 2,560 pounds, or 44,700 pounds per square inch; elongation in 1 inch, 40 per cent.; in 6 inches, 27 per cent.; diameter of fracture, 0.205 inch; reduction of area, 42.3 per cent.

The cold-fracture of this alloy was finely crystalline, and the appearance was similar to that of the alloy containing 0.50 per cent. of bismuth.

Experiment No. 3.—Copper, 60.01; zinc, 39.90; bismuth, 0.09 per cent. Melted 5 pounds of copper, added 1½ ounces of an alloy of copper, 90, and bismuth 10, per cent., and then 3 pounds 6 ounces of zinc. Rolled from 0.660 to 0.485 inch, a reduction of 26 per cent. No cracks appeared during this reduction. Annealed, and the surface of the plate presented an unchanged appearance; no traces of fire-cracks were visible. Rolled to

0.420 inch, a reduction of 13 per cent., and an enormous number of fire-cracks appeared on both sides of the plate. No edge-cracks formed during this reduction. The cracks which were produced during the latter reduction were evidently of a latent nature, like those in Experiment No. 2. They penetrated the plate so deeply that further rolling was impossible. The cold fracture of this alloy was finely crystaline.

Experiment No. 4.—Copper, 59.95; zinc, 40; bismuth, 0.05 per cent. Melted 5.5 pounds of copper, added 0.5 pound of an alloy of copper, 99, and bismuth, 1 per cent., and then 4 pounds of zinc. Rolled from 0.594 to 0.420 inch, a reduction of 29 per cent. No cracks appeared. Annealed, and rolled to 0.319 inch, a reduction of 24 per cent. A few slight edge-cracks formed during this reduction, but otherwise the sheet remained unchanged. Annealed, and fire-cracks appeared on both sides of the sheet. Many of the cracks were so deep that the plate could not be rolled again. Rolled another portion from 0.420 to 0.371 inch, a reduction of 11 per cent., and then annealed. No fire-cracks could be seen. Rolled to 0.325 inch, a reduction of 12 per cent., and *latent* fire-cracks appeared in large numbers. The position of these cracks was different from those on the other plates; many were transverse, others diagonal, and others longitudinal. Rolled without annealing to 0.189 inch, a reduction of 41 per cent. No edge-cracks formed, and the fire-cracks seemed to have become obliterated, which gave the sheet* the appearance of perfect homogeneity. Rolled the sheet still further to 0.058 inch, a total reduction of 84 per cent., and it cracked so badly on the edges that additional reduction was almost impossible.

Experiment No. 5.—Copper, 59.98; zinc, 40; bismuth, 0.02 per cent. Melted 5 pounds and 12.75 ounces of copper, added 3.25 ounces of an alloy of copper, 99, and bismuth, 1 per cent., and then 4 pounds of zinc. Rolled from 0.590 to 0.504 inch, a

* When such sheet is rolled, cracks of this nature either close so as to become invisible to the naked eye or form slivers, by the edges of the cracks overlapping one another and then becoming rolled down. The invisible cracks do not weld together; and while, under ordinary conditions, they are difficult to detect, they are readily made apparent by polishing the sheet.

reduction of 14 per cent. Did not crack on the edges. Annealed, and rolled to 0.384 inch, a reduction of 23 per cent. Neither edge-cracks nor latent fire-cracks appeared. Annealed, and rolled to 0.052 inch, a reduction of 86 per cent. At the thickness of 0.125 inch slight cracks began to appear on the edges, and at 0.052 the reduction had reached the maximum amount. No fire-cracks were detected during the rolling process. This alloy seemed to roll nearly as well as brass free from bismuth; therefore, 0.02 per cent. of bismuth represents the dividing line between satisfactory and unsatisfactory brass.

The following tests were made on sheet rolled from 0.384 to 0.053 inch, a reduction of 86 per cent.:

	As rolled.	Annealed.
Size, inch	0.482 × 0.0535	0.475 × 0.0535
Length, inches	12	12
Sectional area, square inch	0.0257	0.0254
Breaking strain, pounds	2,816	1,510
Breaking strain per square inch, pounds	109,000	59,000
Elongation in 1 inch, per cent	4	47
Elongation in 8 inches, per cent	1	37
Size of fracture, inch	0.474 × 0.0515	0.365 × 0.039
Reduction of area, per cent	5	44

The fracture of this alloy shows no traces of crystallization, and compares favorably with that of brass free from bismuth or other injurious elements. The comparison of the results obtained by rolling this alloy, with those obtained on pure brass of the same composition, shows that practically the same reductions can be given.

Conclusions.—While it has been known for some time that bismuth is an injurious impurity in brass, the author believes it has not been demonstrated before that this element is a cause of fire-cracks. The reason for this phenomenon is not well understood, but there is evidently a segregation of bismuth or an alloy of bismuth which is devoid of sufficient strength to stand the necessary strain.

The result obtained by Stead, in his researches on the microscopic examinations of alloys, throws some light on the subject.

By the examination of an alloy of copper, 99, and bismuth, 1 per cent., he found that a segregation takes place, and that if such an alloy is bent fracture will take place along the lines of this segregation. It is reasonable to assume that the action of bismuth on brass is similar.

It must not be supposed that all fire-cracks in brass are due to bismuth. As a matter of fact, it is very doubtful whether this element is usually the cause of such trouble; in the majority of instances the amount of bismuth in copper is not large enough to interfere with its employment in the manufacture of brass.

The behavior of these alloys when forged hot is worthy of notice. The alloy containing 0.50 per cent. of bismuth could not be forged at any heat. The 0.25 per cent. alloy behaved in a similar manner. The alloy containing 0.09 per cent. of bismuth would forge to a thin edge, but would fracture when bent. The 0.05 per cent. alloy likewise fractured at the bend. The 0.02 per cent. alloy would forge to a thin edge and bend over on itself, showing but few cracks, but did not behave as well in this respect as brass containing no bismuth.

The results obtained in the preceding experiments are collated in the following summary:

1. Bismuth renders brass cold short, and is similar in this respect to antimony, although the effect is not so marked.
2. Bismuth is a cause of fire-cracks in brass.
3. High brass intended for cold rolling should not contain over 0.01 per cent. of bismuth.
4. Bismuth produces hot shortness in brass.
5. Bismuth is a cause of *latent* fire-cracks in brass.

In the use of the term *latent* in connection with fire-cracks it is the author's belief that while annealing is the cause of their existence, they do not exist as cracks in the metal after annealing, but as lines of inferior cohesion in an apparently homogeneous mass; rolling, however, developes them, and to all appearances they then partake of every characteristic of true fire-cracks. It seems advisable, therefore, to apply such a distinguishing term, especially as *latent* fire cracks are liable to be mistaken for *rolling* cracks.

GAGING THE CIRCULARITY OF BOILER FURNACES.

By T. Messenger, A. M. Inst. C. E.

[Reprinted from "Cassier's Magazine."]

At a recent meeting of the North-East Coast Institution of Engineers and Shipbuilders the writer offered a paper on an instrument for gaging the circularity of boiler furnaces and cylinders, and producing a diagram which has already met with the approval of some of the Board of Trade surveyors, and others most interested in this question, who have seen it.

The invention relates to an instrument or apparatus for internally gaging and testing the circularity of cylinders, and delineating the same on paper, and is designed more particularly for use with cylindrical furnaces.

Of late years the steam pressure in boilers has been greatly increased, particularly in marine boilers of the cylindrical type having circular furnaces. Such furnaces are liable to become distorted after use, and it is necessary to frequently gage them to ascertain any deformation which may exist in them. This has hitherto been usually accomplished by measuring them with a telescopic gage in different directions, but this method is extremely inconvenient and not nearly so exact as if these measurements were taken from the center of the cylinder, *i. e.*, radially.

The object of this invention is, therefore, to take these measurements radially, and to produce a diagram on a sheet of paper showing the deformation, if any, existing in a section of the cylinder as compared with a true circle. It consists in arranging three telescopic legs radiating from a center pin in such a manner that they all move outwards or inwards simultaneously and equally; they are placed at angles of 120 degrees one with the other, so

that when the points of these three telescopic legs rest on the inner surface of the cylinder, the center pin will always be in the center of these three points, as explained further on.

A telescopic arm is suitably arranged and provided with a roller at its outer end, pressed out by a spiral spring, which arm works on the center pin and is moved round the cylinder; the roller moves inwards or outwards as it travels round, following any irregularities in the cylinder, and if a pencil be fixed to the sliding piece in the telescopic arm, and pressed against a sheet of paper, it will describe on it a diagram or representation of the form of the cylinder and show if it be a true circle or any departure therefrom. From these representations it can be seen whether or not any deformation is to be found in that portion of the cylinder tested.

This result is obtained preferably in the following manner: At the inner ends of each telescopic leg a toothed rack is fixed, and a cog wheel gears with each of these racks, the centers of these wheels being equidistant from the center pin. A fourth wheel is placed centrally between, gearing into each of the three, the result being that the center wheel, when turned in one direction, causes the three telescopic legs to move outwards, and if turned in the other direction, causes the three telescopic legs to move inwards, all simultaneously, and to an equal extent.

In placing the instrument into a cylindrical furnace, it is preferred to place one of the three telescopic legs vertically, resting on the bottom of the furnace, and on this leg is placed a spiral spring to take the entire weight of the instrument, which enables it to be much more readily and quickly put in place. When the points of these three telescope legs all touch the furnace they are fixed as follows: On the center-wheel spindle or axis is fixed a worm wheel, with which gears a worm, working in a pivoted frame, so that it can be instantly thrown in or out of gear with the worm wheel; and when the points of the three telescopic legs touch the inside of the furnace, the worm then gearing with the worm wheel, and being turned in one direction, immediately presses the points of the three telescopic legs outwards and locks them there, thus firmly fixing the instrument in position; the

worm being turned in the opposite direction, as readily releases the instrument.

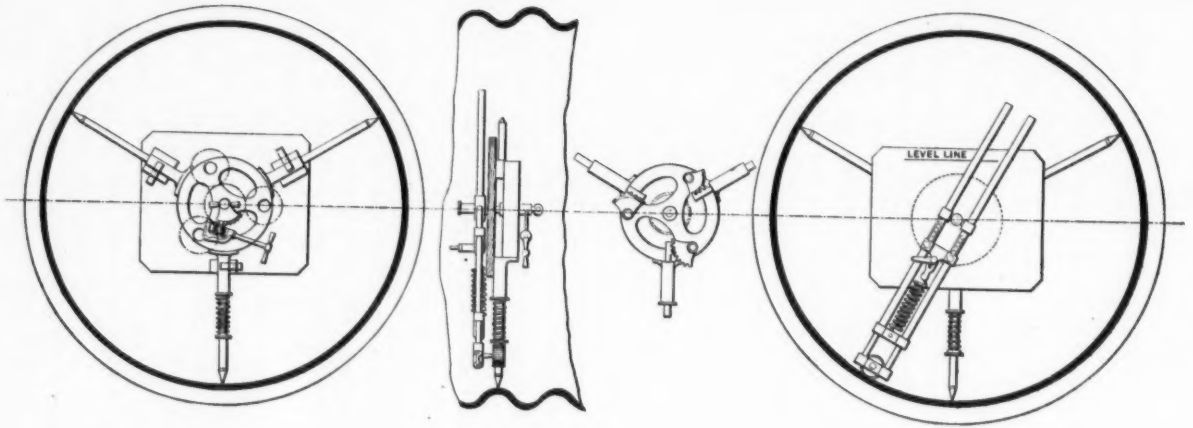
This worm wheel is on one side of the instrument, and the central pin first referred to is on the other side. On the central pin is suitably secured a drawing board on which a sheet of paper is fixed, and from the foregoing description it will be readily understood that if the telescopic arm, having a roller at its outer end, be moved around the furnace, and the pencil, attached to the outer portion of this arm which moves inwards or outwards with the roller, be brought into contact with the paper, a diagram will be produced accurately showing if the furnace be true or deformed. Although the pencil will revolve in quite a small circle compared with the furnace, yet the deformities, if any, will remain full size, and therefore will be apparently magnified in proportion to the circle. This enables these deformities to be much more easily read by the eye, and they can be measured as if they were full size.

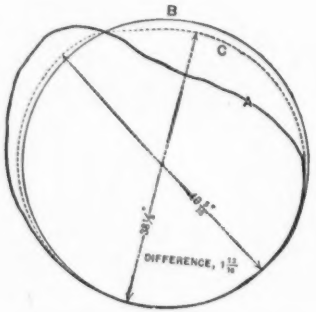
It will be understood that several sets of telescope legs are required. The first set will take furnaces from 33 inches to 37 inches; the second, from 36 inches to 40 inches; the third, from 39 inches to 43 inches; and so on. The radial arm will take any furnace from 33 inches to 52 inches, and up to 60 inches, if required.

The instrument, when used in gaging a steam cylinder, should have the roller replaced by a pointer having a slightly rounded point, so as not only to show any deviation from a true circle, but also any scoring which generally exists in a worn steam cylinder.

The great importance of the diagram, when taken, is that it considerably magnifies any defects, and at the same time shows clearly at sight which are the major and minor diameters, thereby suggesting exactly the angles at which these dimensions should be taken when furnaces are examined for deformity, and also showing the boiler maker in which direction the furnaces require to be set into truth.

The pencil is preferably so set in the instrument as to describe a figure of a convenient size to suit a sheet of foolscap paper;


LEVEL LINE


B
C
DIFFERENCE, $1\frac{13}{16}$

and as this paper is usually soiled, it is best to take a tracing of this figure to be kept as a future record, and for comparison, say, every year, to ascertain the increase of deformation, if any.

The manner in which the pencil magnifies the evils when drawing the figure *A*, shown in one of the annexed illustrations, is very startling, and unless this is clearly understood it might lead to needlessly condemning a furnace. But this method of magnifying the evils is exactly that adopted when showing the profile of a railway, viz: the vertical scale being greater than the horizontal; otherwise the inclines would scarcely be seen, just as with this instrument any small deformity in the furnace is made apparent which otherwise would escape attention.

For finding the true circle *B*, to compare by scale with the figure *A*, an easy method is to bend a small lead wire around the figure *A*. This, opened out straight, gives the length of the circumference for obtaining the diameter of the true circle *B*, for this comparison; or a cyclometer may be used.

The dotted line *C*, is reduced from figure *A* to the same scale as the true circle *B*, and the comparison of these two figures, viz: *C* and *B*, gives the true delineation to scale of what the real deformity is, and thus enables a true opinion to be formed at a glance, at the same time correcting the startling effect of that produced by the figure *A*, which so greatly magnifies these defects.

When measuring furnaces for deformity, as has hitherto been the custom, by an ordinary telescopic gage, only two diameters are generally taken in different directions, and these diameters entered in a proper form in figures, the subtraction of one from the other giving the difference, and so when wading through a sheet of these figures, say, for a vessel having 48 furnaces, one's mind becomes mystified before completing the investigation.

The great point in the magnified diagram is that it at once very clearly brings to one's mind the real defects of each furnace, and at a glance showing the real form in every point of its circumference.

The diagram is first taken with the instrument in each furnace, this, at a glance, showing in which direction they should be

measured for the major and minor diameters, and also to the boiler maker in which direction to apply the hydraulic jack, so that this part may be dealt with. The sheets of paper on which these diagrams are described are then taken to the office, and the scale for drawing the true circle *B*, is ascertained, as before explained. Having found this scale, the dotted circle *C*, is developed by radial ordinates to this scale; then these two circles *B* and *C*, show to scale exactly what the deformity is.

HIGH PRESSURE AT SEA WITH SOME CONSIDERATION OF TYPES OF BOILERS.

By W. R. Cummins.

[Reprinted from "Marine Engineering."

In the boilers under question (Yarrow, Thornycroft, Normand, Reid and Blechynden) the gases, after leaving the combustion chamber, are well split up and distributed over the heating surface, but the distance traveled by the gases before they pass into the uptake is so small that it will be impossible to lower the temperature of the gases to an economical point. For instance, the mean distance traveled by the gases from the firebars to the uptake is only about 5 feet in the Yarrow boiler, and somewhat more in the other varieties, against 17 feet in the Scotch boiler. As regards weight of water over the highest heating surface, these boilers are so deficient that an automatic feed arrangement is desirable. For instance, in the three boilers taken as an example the weight of the water at 6 inches over the highest heating surface is about 2,625 pounds; that is to say, the surface would be exposed if the feed were shut off for only ten minutes. These boilers are very accessible for cleaning, examination, and repairs, except those with curved tubes. As the whole of the surface exposed is composed of tubes, it is an easy matter to renew the whole or any part of them. All these boilers have lower drums shielded from the heat of the furnace, where grease and mud may collect without doing harm. The circulation of water in these boilers is natural, and leaves nothing to be desired. This, combined with their form, renders straining from unequal temperatures impossible, and allows steam to be raised in a very short time without the trouble of mechanical circulation. Finally, as to cost of construction, they should be

one-half that of a Scotch boiler of the same heating surface and grate.

Hence boilers of this type, if built with straight tubes of fairly large diameter, would fulfil all the conditions enumerated before as necessary for a good boiler, except that of the time the gases are exposed to the heating surface, and the weight of water above the highest heating surface; the first point largely affecting the fuel economy, a very vital consideration with boilers for the mercantile marine, and the second point affecting the ease and confidence in working. The other class of water-tube boilers, comprising the Belleville, the D'Allest, the Babcock & Wilcox and the Niclausse, have as a common feature rows of water tubes slightly inclined to the horizontal, with their ends connected in various fashions to "headers," in order to effect the circulation of water through the tubes.

As regards the thickness of the heating surface, these boilers are under the same favorable conditions as the other class of water-tube boilers. As regards size of combustion chamber, they are, generally speaking, deficient. For instance, take three Belleville boilers of the same grate surface (118 square feet) as the two Scotch boilers we have been using as examples. The volume of the combustion chambers for these three boilers amounts to only 255 cubic feet, against 480 cubic feet for the Scotch boiler, and 525 cubic feet for the other class of water-tube boilers. Besides the deficiency in volume, they are of insufficient height, the consequence being that whenever fresh fuel is put on, some of the liberated gases reach the lower row of tubes before they have time to get heated up and combined. They pass among the tubes unconsumed until they reach the uptake. If they meet a hot current of gases from another boiler they will burn in the uptake; if not, they will pass up the funnel unconsumed. The former event is probably what happened during the first trials of H.M.S. *Powerful*, when the base of the funnel became red hot. The evils of a shallow combustion chamber are aggravated by a thick fire, and to get good results with a combustion chamber of this type needs a thin fire and firing little and often.

One of the features of the Belleville boiler is the arrangement

of air jets above the firebars. These jets serve two purposes: First, they tend to secure a better combustion than would otherwise be possible; and, secondly, they tend to protect the lower row of water tubes, which apparently sometimes suffer from overheating. As regards the splitting up of the gases after leaving the combustion chamber, and their distribution over the heating surface, the boilers of the type we are considering are quite equal to any of the types before considered, and as regards the distance traveled by the gases, before they pass away to the uptake, they are very superior to the other class of water-tube boiler. For instance, in the three Belleville boilers used as before for comparison, the mean distance traveled by the gases from the firebars to the uptake is about 9 feet, compared with about 5 feet in the Yarrow boiler.

As regards the weight of water carried above the highest heating surface, this type of boiler is provided with a drum connected with the front and back headers, and if the drum is of sufficient capacity, a large weight of water can be carried over the highest heating surface. The Belleville boiler is, however, worked in a special manner and requires a feed regulator. As regards accessibility and convenience for repairs, this class of boiler is very well off, except, perhaps, in the matter of cleaning the tubes externally, especially in cases where deflectors are placed on the tubes. The tubes are all straight, of large diameter, and uniform length, thus dispensing with the necessity of carrying a great number of spare tubes and allowing for internal inspection of each tube. A majority of these boilers are provided with a mud drum at the bottom, where sediment may collect and be removed at intervals. The circulation of water in this class of boiler is satisfactory, provided the tubes are of sufficiently large diameter, and the fires are not much forced. With small tubes and forced draft there is a risk of burning the lower tubes, owing to failure of the circulation. If there is any risk of this, and the headers are in one piece from top to bottom, they should be sufficiently flexible to allow for the unequal expansion of the top and bottom rows of tubes, as cases have happened of cracked headers due to this cause. As regards cost of construction and space

occupied, this class of boiler is inferior to the other class of water-tube boiler, but much superior to the Scotch boiler.

Summing up, we may say that the Scotch boiler working at 250 pounds pressure would burn the fuel well and utilize the heat satisfactorily; it would contain plenty of water to allow for irregularity in the feed; it would be not quite so accessible as the lower-pressure boilers of the same type, and would have the same defects as to repairs of the internals. The danger from the presence of grease would certainly not be less, and the circulation would not be better. Extra care would be needed in raising and letting down steam to avoid straining from unequal temperature. Finally, the cost of construction would be more than that of the lower-pressure boiler, and the space occupied only very little less.

The water-tube boilers of the Thornycroft, Yarrow, Normand, etc., type would burn the fuel well, but would not utilize the heat satisfactorily; they would have very little water to allow for irregularities in the feed, they would be very accessible for cleaning, and convenient for repairs. The circulation would be good, and there would be no danger of straining or leakage through unequal expansion. Finally, the cost of construction would be vastly less than that of the Scotch boiler and the space occupied considerably less.

The water-tube boilers of the Belleville, Babcock & Wilcox, etc., type would not burn the fuel well, but would utilize the heat satisfactorily; they would have sufficient water in them to allow for irregularity of feed, would be fairly accessible for cleaning, and convenient for repairs. If not pressed the circulation would be good, and there would be no danger of straining when raising steam or from unequal expansion. Finally, the cost of construction and the space occupied would be considerably less than that of the Scotch boiler.

There are up to the present, very few published trials of water-tube boilers on which any reliance can be placed, as the majority of them have been carried out by measuring the feed-water pumped into the boiler, but how much of this has been turned

into steam is not known. The coal consumption trials of H.M.S. *Sharpshooter* and H.M.S. *Powerful* give the combined efficiency of the engines and boilers, which is very satisfactory, compared with similar trials of the Scotch boiler, but how much this good result depends upon the higher boiler pressure and how much on the boiler itself is not known.

We can now pass on to discuss questions as to the best design for an engine suitable for 250 pounds working pressure. The first question which arises is, Into how many stages should the expansion be divided? When the triple-expansion engine was first introduced, and effected a saving of 25 per cent. in the coal consumption, its main source of economy was attributed to the use of three stages in the expansion, giving a small temperature range in each individual cylinder. This theory has of late years been to some extent discredited. The only method of getting at the truth would be to carry out a scientific experiment with engines indicating about the same power, with the same boiler pressure and number of expansions, one with two cylinders and two-stage expansion, and the other with three cylinders and three-stage expansion. No amount of theorizing will lead to any reliable conclusion, and Professor Weighton's experiments on this subject will be awaited with interest.

As pointed out in the beginning of this paper, the economy due to raising the boiler pressure from 80 pounds to 150 pounds is theoretically about 23 per cent. As the maximum economy claimed by the triple-expansion engine over the compound is not more than 25 per cent., there is no need to call in the three-stage expansion to account for the economy. The total temperature range for steam of 80 pounds boiler pressure is 171 degrees Fahrenheit; this, divided into equal stages, gives a range of 85.5 degrees Fahrenheit for each cylinder. The total temperature range for 150 pounds boiler pressure is 213 degrees Fahrenheit; this, divided into three equal stages, gives a range of 71 degrees Fahrenheit in each cylinder. That is to say, there is only a difference of 14 degrees Fahrenheit, under the most favorable conditions, between the temperature range of the compound and the triple-expansion. Hence, in default of experiments on tem-

perature range, we need not tie ourselves down to multiple-expansion stages on account of steam economy.

The next question is that of number of cranks. The three-crank engine has now almost displaced the two-crank engine, on account of its more equable turning and balance, and four-crank engines are now coming into favor. The four cranks offer great facility for balancing the moving parts, and should, therefore, be adopted for a high number of revolutions, and where absence of vibration is of importance. They will, however, occupy more space fore and aft, thus necessitating a longer engine room, unless special means are taken to make the engine short.

The next point is the arrangement of cylinders. In the first place, tandem cylinders should only be used in cases of absolute necessity, owing to the inconvenience of overhauling the lower cylinder. Then, with three cranks, we may have two arrangements of cylinders, viz: (1) one high pressure and two low pressure; (2) one high pressure, one intermediate, and one low pressure. With four cranks, three arrangements are possible, viz: (1) two high pressure and two low pressure; (2) one high pressure, one intermediate, and two low pressure; and (3) one high pressure, one first intermediate, one second intermediate, and one low pressure.

The most important qualifications for economy of design and working are:

First, the initial loads in each cylinder should be equal. Second, the cut-offs should be as late as possible, and practically equal in each cylinder, and so arranged that when working at the maximum voyage power the valve gear will be operating at its maximum efficiency. Third, the "drop" between the cylinders should be as small as possible consistent with economy of size of cylinders.

It is important to design engines with equal initial loads. It is invariably the practice to make the connecting rods, piston rods, crank shaft and main bearings in duplicate for each engine. Hence, if the initial loads are unequal, these parts must be designed for the maximum initial load. Speaking generally, the weight of the moving parts is proportional to the initial load and

a function of the stroke, so that if a four-cylinder engine is designed with unequal loads, and the maximum is, say 10 per cent. greater than it would be with equal loads, then the weight of the moving parts of all four engines would be 10 per cent. greater than necessary. The weight of the frame work of the engine is also affected by the initial loads; in fact, the total weight of engines of the same type should vary directly as the sum of the initial loads and some power of the stroke. It is also an advantage to have the cuts-off in each cylinder as nearly equal as possible. With the link motion there is a particular point of cut-off where the maximum efficiency is attained—that is to say, where the mean speed of steam during the admission is a maximum with a given value of travel. It will be seen that the later the cut-off the better the result, and that the efficiency falls off rapidly for cuts-off at less than 50 per cent. The cut-off in the high-pressure cylinder should not be much less than 50 per cent. when linked up, as the later the cut-off the less is the proportionate loss from clearance, and an earlier cut-off than this in the other cylinders would mean a large increase of admission speed in the very cylinders where it is most difficult to get sufficient steam opening.

The best conditions as regards "drop" will be obtained if there is no drop, or a drop of a few pounds at the minimum voyage power (*i.e.*, ship in ballast), which will give a reasonable drop for the loaded ship horse power.

Although, as pointed out above, we need not tie ourselves to multiple-expansion stages on account of any expected economy due to lessened temperature range, yet the use of more than one stage has the important effect of diminishing the sum total of the initial load, and, generally speaking, the more stages we use the less will be the total loss from drop.

Taking a cylinder 49 inches in diameter, with 4 pounds back pressure and 250 pounds initial pressure in the cylinder, the total initial load would be 463,700 pounds. If, however, the expansion were divided into two stages, the total initial load would be, with cylinders 15½ inches by 49 inches, the combined initial load would equal 85,200 pounds, a reduction of no less

than 80 per cent. on the single-stage load. Of course the actual reduction in weight would not be so much as this, as the weight of one engine with a certain initial load will be less than the combined weight of two engines with the same combined initial load.

For two-stage three-crank engines with cylinders 15½ inches by 34½ inches by 34½ inches, the combined initial loads = 115,415 pounds, an increase of 35 per cent. over the combined loads for the two-stage two-cylinder arrangement. For the three-stage three-cylinder engine, with cylinders 15½ inches by 26½ inches by 49 inches, the combined initial load = 95.700 pounds, rather more than with the two-stage two-cylinder arrangement.

For the three-stage four-cylinder arrangement, with cylinder 15½ inches by 25½ inches by 34½ inches by 34½ inches, the combined initial load = 118,900 pounds, an increase of 24 per cent. over the three-stage three-cylinder arrangement.

For the four-stage four-cylinder arrangement, with cylinders 15½ inches by 22 inches by 32 inches by 49 inches the combined initial load = 98,500 pounds, a slight increase over the three-cylinder three-stage arrangement.

The table below shows the above figures put together:

Arrangement.	Cylinders.	Combined initial load.
Single stage	49	463,700
Two-stage, 2 cylinders	15½ × 49	85,200
Two-stage, 3 cylinders	15½ × 34½ × 34½	115,400
Three-stage, 3 cylinders	15½ × 26½ × 49	95,700
Three-stage, 4 cylinders	15½ × 25½ × 34½ × 34½	118,900
Four-stage, 4 cylinders	15½ × 22 × 32 × 49	98,500

Boiler pressure, 250 pounds.
Total expansions, 18½.
Equal initial load in each cylinder.
Cut-off in first cylinder, 54 per cent.

From which it will be seen that the worst results after the single-stage arrangement is attained by the divided low-pressure cylinder arrangements.

The following table shows the cuts-off in each cylinder to give equal initial loads with the above cylinder ratios:

Two stage, 2 cylinders...	Cylinders	15½	49		
or two-stage, 4 cylinders,	Cuts-off, per cent	54	42		
Two-stage, 3 cylinders...	Cylinders	15½	34½	34½	
	Cuts-off, per cent	54	27	27	
Three-stage, 3 cylinders,	Cylinders	15½	26½	49	
	Cuts-off, per cent	54	54	54	
Three-stage, 4 cylinders,	Cylinders	15½	25½	34½	34½
	Cuts off, per cent	54	51	33	33
Four stage, 4 cylinders...	Cylinders	15½	22	32	49
	Cuts off, per cent	54	55	55	57

From which it will be seen that the greatest uniformity of cut-off is attained by the three-stage three-cylinder, and the four-stage four-cylinder, and that the cuts-off in the divided low-pressure cylinders are impossibly early.

The two-stage two or four-cylinder arrangement may be arranged to have equal initial loads, and equal cuts-off by increasing the high pressure cylinder as shown below:

Two-stage, 2 cylinders	Cylinders	20½	49
or two-stage, 4 cylinders,	Cuts-off, per cent	30	30

Combined initial load = 138,700.

With the two-stage three-cylinder, and the three-stage four-cylinder, it is impossible to get equal initial loads and equal cuts-off unless the terminal pressure in some of the cylinders is below the back pressure.

The latter arrangement of two-stage two or four-cylinder would be suitable if equal loads and equal cuts-off were desired, and if the total expansions were, say, 10½ instead of 18½, thus making the cuts-off in each cylinder 54 per cent. Of course this arrangement entails an addition of 60 per cent. to the total initial load of the unequal cut-off arrangement. It will be interesting at this point to give the actual initial loads of some three-stage four-cylinder engines. These below are for H.M. cruiser *Powerful*, the particulars being taken from the published indicator cards taken on her trial trip.

H.M.S. *POWERFUL.*

High pressure, pounds	= 213,000
Intermediate pressure, pounds	= 219,300
Low pressure, pounds	= 104,300

It will be noticed that the initial load on each low-pressure cylinder is less than one-half the load on the high-pressure and the intermediate-pressure cylinder. If the initial loads had been equal the load on each cylinder would have been 177,000 pounds. The load on the intermediate-pressure is, however, actually 219,300 pounds, and as the rods, etc., are of the same scantlings throughout, the weight of the moving parts and the surface of the principal bearings are approximately 25 per cent. greater than would have been necessary with equal initial loads. The author is not aware of the reason for this. Probably the equal initial loads would have entailed a too early cut-off in the low-pressure cylinders, and consequent insufficiency of steam opening; or perhaps the size fixed upon for the intermediate cylinder would, with equal initial loads, have brought the terminal pressure of that cylinder below the back pressure; or it may have been deemed expedient to keep the pressure in the low pressure steam chest as low as possible to minimize the load on the slide valves.

We can now consider the question of "drop" between the cylinders. To attempt to determine the theoretical loss due to drop would involve a very complicated calculation. In the first place, when steam expands without doing external work, it becomes superheated, or, if it contains moisture, some of the latter will be evaporated; and in the second place, a given drop at a low pressure will not cause so much loss as the same drop at a higher pressure, as high-pressure steam is more valuable to us than low-pressure steam. Hence, to simplify matters, the drop in the following remarks has been calculated as the area or areas under a $\frac{1}{9}^0$ curve drawn from the terminal pressure in the cylinder to the back-pressure line of the cylinder. The proportion which this area bears to the area under a $\frac{1}{9}^0$ curve with the same initial pressure, back pressure, and expansions, as the cases under consideration, have been called the "percentage of loss due to drop."

The following table shows the comparative loss from drop of the different types of engine we have been considering:

Type.	Initial loads and cut-off.	Cylinders.	Drop.	Loss due to drop.
			Pounds.	*Per cent.*
Two-stage, 2 or 4 cylinders	Equal loads Unequal cuts-off.	$15\frac{1}{2} \times 49$	81	15
Two-stage, 2 or 4 cylinders	Equal loads Equal cuts-off	$20\frac{1}{2} \times 49$	25	2
Two-stage, 3 cylinders	Equal loads Unequal cuts-off.	$15\frac{1}{2} \times 34\frac{1}{2} \times 34\frac{1}{2}$	75	10
Three stage, 3 cylinders	Equal loads Equal cuts-off	$15\frac{1}{2} \times 26\frac{1}{2} \times 49$	42 12	$4\frac{1}{2}$
Three stage, 4 cylinders	Equal loads Unequal cuts-off.	$15\frac{1}{2} \times 25\frac{1}{2} \times 34\frac{1}{2} \times 34\frac{1}{2}$	21 1	1
Four-stage, 4 cylinders	Equal loads Equal cuts-off	$15\frac{1}{2} \times 22 \times 32 \times 49$	1 1 2	$\frac{1}{2}$

From which it will be seen that the best result is attained by the four-stage cylinder type, and the worst by the two-stage two or four-cylinder type, with equal initial loads and unequal cuts-off.

A NEW HIGH-DUTY RECORD FOR PUMPING ENGINES.

[Reprinted from "Engineering News."]

We have received a copy of a report made by Prof. W. F. M. Goss, M. Am. Soc. C. E. of Purdue University, of a test of a 20,000,000-gallon triple-expansion pumping engine, built by the Snow Steam Pump Works, Buffalo, N. Y., for the Indianapolis Water Co., under the superintendence of Mr. L. K. Davis, consulting engineer, 220 Broadway, New York city. The results give the remarkable figures of 150.1 million foot pounds of work per million British thermal units, and 11.26 pounds of dry steam per I.H.P. per hour. This duty figure, we believe, is the highest ever recorded on the heat unit basis, although the steam consumption per I.H.P. per hour is not quite so low as that obtained by the Leavitt triple-expansion engine at Chestnut Hill station, Boston, viz: 11.2 pounds (Peabody's Thermodynamics, 4th ed., p. 355). That the figures are open to some question is apparent from the comments on them made by Professor Goss himself, which we quote below, and it is to be hoped that another test of the engine may ere long be made, in which the water consumption may be measured by the feed water used in the boiler as well as by the water discharged from the hot well, the latter method being the only one used in Professor Goss' test.

The test was made on July 8, after a preliminary run to give practice to the observers had been made the day before. The engine was in charge of Mr. E. C. Sornberger, representing the Snow Steam Pump Works, and the Indianapolis Water Co. was represented by Mr. John Rail. Some of Professor Goss' comments on the test given in his report to Mr. F. A. W. Davis, vice-president of the Water Co., are as follows:

"Viewed as a piece of experimental work, the test was a most satisfactory one. The methods followed were carefully chosen, the apparatus employed was known to have been in excellent order, the desired conditions of running were well maintained, observers were employed in such number as to allow the work of each one to be easily performed in the time assigned, all observers were skilled engineers, and they were especially drilled by a trial run. It would appear, therefore, that the results as presented possess a degree of accuracy which is fully equal to that usually attained in the course of such work.

"The duty disclosed by the data exceeds by a liberal margin that obtained in any test, the results of which have thus far been published. The famous Milwaukee engine, known to engineers the world over, gave a duty of 127.1 million, which is to be compared with the 150.1 million delivered by the Indianapolis engine.

"*Leakage.*—Very careful tests were made by the undersigned, and later by Mr. Rail, to determine the amount of water leaking past valves and plungers. It was found that leakages from all sources combined amounted to but a few thousandths of one per cent. of the water pumped, justifying the conclusion that for all purposes, either practical or theoretical, the pump is tight. The significance of this statement will be better appreciated when it is considered that the pump contains 540 suction valves and 540 delivery valves, or a total of more than a thousand valves. A defect in a single one of these would have been disclosed by the tests which were made.

"*Capacity.*—During the eight-hour test, the lowest rate of speed for any five-minute interval was 17.6 revolutions per minute, the highest was 23.4 revolutions per minute, and the average speed for the whole eight hours was 21.46 revolutions per minute. This speed gives the pump a capacity of 20.6 million gallons per twenty-four hours.

"*Friction.*—The difference between the work done by the steam on the pistons and that delivered by the plungers is the work absorbed by the engine in the form of friction. The data show that but 4.6 per cent. of the indicated power was lost in this way.

This is unprecedentedly small. It is altogether probable that a more elaborate test, in which special attention is given to the indicator work, may change this figure, since the relation is such that a change of 1 per cent. in the indicated power would produce a change of 20 per cent. in the value of engine friction. For the present, however, the figure given represents the best information that is to be had, and there is nothing in the data to discredit it.

"*Steam Consumption per Horse-Power per Hour.*—The performance of steam engines is often expressed in terms of the weight of dry steam required per horse-power per hour. A determination upon this basis for the engine tested gives a consumption of 11.26 pounds. This, so far as the undersigned knows, is less than is required by any engine the results of which have ever been reported. It is evident, therefore, that the engine excels both in the domain of hydraulic engineering and in that of steam engineering as well. [11.2 pounds has been reported for the Chestnut Hill engine.—Ed. Eng. News.]

"*Conclusion.*—The preceding paragraphs prove the engine tested to be a very unusual one, and that a definite determination of its performance will demand unusual skill and care. The test herein described was undertaken upon the supposition that the engine could be tested by methods usually employed in such work, and that its performance would fall within the range of ordinary results. It has been advanced by careful, painstaking and conservative methods, and it is believed that the facts disclosed may be accepted with as much confidence as those ordinarily resulting from such work. It appears, however, that these facts tell a story so unusual as to give rise to a question concerning their accuracy. It goes without saying that processes which would stand unquestioned when they lead to commonplace results are carefully scrutinized when they point to an exceptional result.

"The undersigned is not disposed to question unduly or to discredit in the least degree the material facts which are herein presented, but, for reasons stated, he would earnestly recommend that they be looked upon as tentative until they can be verified by a test conducted on a broader plan. What is needed is an array

of data so elaborate that the action of every part of the machine may be completely analyzed, so that the facts as stated can be reinforced by evidences of such a character that it cannot be questioned. I hope, therefore, that your company may see its way clear to undertake at an early date an investigation which will comport with the high efficiency which will be disclosed by it."

The results obtained in the test are condensed as follows from Prof. Goss' report:

Cylinder diameters, inches; H.P., 29; intermediate, 52; L.P.	80.
Pump, plunger diameter, inches	33.
Stroke of all pistons and plungers, inches	60.
Duration of tests, hours	8.
Revolutions, per minute	21.46
Steam pressure at engine, gage, pounds	155.6
Barometric pressure, pounds	14.3
Temperature of water, pumped, degrees Fahrenheit	56.5
Temperature of discharge from condenser, degrees Fahrenheit	79.5
Temperature of discharge from hot well, assumed as temperature of feed, degrees Fahrenheit	111.7
Observed weight of water that passed weighing barrels, pounds	68,648.
Weight of water discharged from hot well, assuming that 3 per cent. was vaporized before reaching weighing barrels	70,771.
Weight of water that leaked through condenser during test. To be subtracted, pounds	60.
Moist steam used by engine, pounds	70,711.
Moisture in steam, per cent	1.2
Dry steam used by engine, pounds	69,862.
Water pressure against which pumps delivered, pounds	80.
Total pressure against which pumps were operated, suction lift included, pounds	88.7
Total H.P. delivered by pumps	740.
Water shown by leakage test to have leaked by plungers and valves during test, pounds	31.4
Horse power, by indicator:	
H.P. cylinder, head end	143.5
H.P. cylinder, crank end	132.1
I.P. cylinder, head end	125.5
I.P. cylinder, crank end	121.2
L.P. cylinder, head end	129.9
L.P. cylinder, crank end	125.3
Total	775.5

Dry steam per I.H.P. per hour, pounds	11.26
Total heat in 1 pound steam, at a gage pressure of 155.6 pounds and containing 1.2 per cent. of water, B.T.U.	1,184.1
Heat in 1 pound water at temperature of hot well, 111.7 degrees Fahrenheit, B.T.U.	79.7
Heat taken from each pound of steam, B.T.U.	1,104.4
Heat consumed by engine, B.T.U.	78,093,000.
Results:	
Duty per 1,000 pounds of dry steam used, as defined by contract, foot pounds	167,800,000.
Duty per million B.T.U., foot pounds	150,100,000.
Capacity per twenty-four hours, gallons	20,600,000.

NOTES CONCERNING METHODS USED IN TEST.

Duration of Test.—As the test did not involve measurements at the boiler, 8 hours were considered a sufficiently long period to give results possessing a high degree of accuracy.

Temperature of discharge from condenser is the average of readings, taken at 10-minute intervals, from a thermometer placed in the pipe between condenser and air pump.

Temperature of discharge from hot well is the average of readings, taken at 10-minute intervals, from a thermometer placed in the hot well. The increase in temperature of the hot well over that of the condenser is due to the discharge of hotter water from the jackets into the hot well.

Water from the hot well is, under normal conditions, led to a feed pump attached to the plunger of the low-pressure engine, which forces it back to the boiler. For purposes of the test the feed pump was disconnected and its supply pipe blanked so that no water could pass it. It was assumed, however, in calculations incident to the test, that the temperature of the water delivered from the hot well was the temperature of the feed.

It has previously been noted that all water leaving the hot well is assumed to represent steam used by the engine. It came from three general sources, namely: From within the cylinders, from the jacket of the cylinders and the coils of the intermediate receivers, and from the drainage pockets between the cylinders. No effort was made to separate the steam from these several

sources. There were no drains or pipes leading steam or water away from the engine which were not connected with the hot well.

The hot well is, however, provided with an overflow and a suction pipe leading to the boiler feed pump, but, as already noted, these were blanked in anticipation of the test. A small vent pipe leading from the top of the hot well was not blanked, but it was observed during the test that nothing escaped from its outer end.

Again, there was a small cold-water pipe, the exhaust of a cellar pump and the exhaust of an air pump connected with the hot well; but, for purposes of the test, joints were broken except in the case of that of the air pump, which machine was not used during the test.

It is thought that these precautions were sufficient to ensure the delivery of all steam, chargeable to the engine, to the weighing barrels placed beneath the hot well.

Finally, the scales upon which the weighings were made were calibrated with 50-pound standard weights and found to balance perfectly. There seems, in fact, to have been no possible chance for error in the observed weight of steam used by the engine, unless there was vaporization of water as it passed from the hot well to the weighing barrels, or a leak through the condenser. The extent of errors arising from these sources is next considered.

Weight of Water Discharged from Hot Well, assuming that 3 per cent. was vaporized before reaching the weighing barrels.— Any loss of water between the hot well and weighing barrels would apparently improve the performance of the engine. That there was some loss by vaporization cannot be doubted, since a slight amount of steam was always to be observed about the barrels. As, however, the temperature of the water delivered was but 111 degrees Fahrenheit, it was thought at the time of the test that the effect of such losses would be entirely negligible. A review of the data, however, indicates the probability of a measurable loss from this cause, and it has been decided to fix its value at 3 per cent. It could not have been greater than this, and if less it will be safe to reserve the establishing of this fact for a later test. This conclusion has the effect of raising the

observed weight of steam used by the engine (68,648 pounds) to 70,771 pounds.

Weight of Water Leaking Through Condenser.—Any leakage of cooling water into the steam of the condenser would apparently impair the performance of the engine.

The water space of the condenser constitutes in effect a portion of the main suction pipe of the engine. Under the conditions of the test there is a difference of pressure tending to produce leakage of about 10 pounds. As a preliminary to the main test, a man hole in the lower part on the steam side of the condenser was opened, a valve in the main suction outside of the condenser was closed, and a primer delivering water from the force main to the suction was opened by such an amount as would maintain a water pressure on the condenser of 10 pounds, thus producing, for the purposes of a leakage determination, the same difference of pressure which exists where the engine is under normal working conditions. The amount of leakage thus determined amounted to but 7.5 pounds per hour, an amount which, while insignificant, has nevertheless been carried forward in the calculations as a correction, its value for the 8-hour test being 60 pounds. The results prove the condenser to be exceptionally tight.

Percentage of moisture in steam was determined by a calorimeter applied to the main steam pipe close to the throttle of the engine.

Leakage by Plunger and Valves.—The sum of the various leakage amount to but 31.4 cubic feet for the whole test, or about 0.003 per cent. of the total volume pumped. It is evident that so small a leakage is entirely negligible, and it is so recorded under the head of results.

Results.—Duty as defined by contract is the number of foot pounds of work done "per 100 pounds of coal, assuming an evaporation of 10 pounds of water per pound of coal." This statement is indefinite, but for the purpose of this report it is assumed to be equivalent to the foot pounds of work done by the pumps per 1,000 pounds of dry steam under the conditions of pressure prevailing during the test. That is, the duty as de-

fined by the contract is assumed to be the area of plunger in square inches multiplied by total pressure against which engine was used multiplied by length of stroke in feet multiplied by total number of single strokes multiplied by 1,000 divided by pounds of dry steam used.

Duty on basis of a million B.T.U., as defined by the American Society of Mechanical Engineers in their Transactions (Vol. XII, p. 534), is area of plunger in square inches multiplied by total pressure against which pumps were used multiplied by length of stroke in feet multiplied by total number of single strokes multiplied by 1,000,000, divided by heat consumed by the engine.

NOTES.

The annual report of the Engineer-in-Chief will have been read by most of the members of the Association before this number of the JOURNAL reaches them, either in the full copy or in synopsis as given by the various leading newspapers; but the additional importance of the report this year, due to the extraordinary conditions of war which affected so radically the operations of the Bureau of Steam Engineering, prompts the reprinting of the following digest of it here, in the belief that many of our readers will be glad to again peruse the principal points of this valuable paper. The "Engineering News" formulates the synopsis as follows:

The annual report of Commodore Melville, Chief of the Bureau of Steam Engineering, to the Secretary of the Navy, covers a period of most unusual activity, and the report shows that this bureau has well met the extraordinary emergency demands placed upon it.

The work immediately necessary on the breaking out of the war was not so much extensive repairs to ships in commission as the fitting out of every available ship in ordinary, with the view of getting some service out of each in an emergency. In three of the old monitors at League Island worn-out boilers were replaced by new ones in thirty days, by the Babcock & Wilcox Co.; and this was done without cutting the decks, the boiler sections being passed through the smoke-pipe openings. The greatest amount of labor was expended in fitting out 110 vessels of the auxiliary navy, purchased, chartered or transferred to the Government. Few of these vessels were provided with evaporators or distillers, and they all required outfits of stores and tools. After leaving the yards a number of these ships were partially disabled, as a result of the novelty of the machinery to the crews and the emergency of war which made it necessary to start them out be-

fore the men were familiar with this new machinery. One result of this experience is the demonstration of the importance of modernizing and stocking the naval station at Key West, the least accessible of all our stations. The greatest amount of repair and outfitting work was done at the New York Navy Yard; and of the 86 vessels repaired there during the fiscal year, 73 were handled in ninety days. At the Norfolk Navy Yard 72 vessels were repaired and fitted out in the year; of which 46 came within the ninety-day limit. At Key West repairs were made to 64 vessels in the last year, and to 37 more in July of the present fiscal year.

The report deals in detail with the condition of the machinery of our naval vessels completed and authorized prior to March 2, 1883, and in nearly every case engines and boilers are rated as "good." A similar report of conditions and progress is given of vessels completed or building during the year ending August 1, 1898.

Under the head of material, it is noted that nickel-steel engine forgings have been brought to a high degree of perfection; and seamless-drawn steel boiler tubes have been made of a degree of excellence undreamed of a few years ago. These seamless-drawn steel tubes, with wrought-steel flanges welded on, are now substituted for the copper and brass steam and feed pipes on destroyers and torpedo boats. Owing to the temperature corresponding to the high pressures carried on these boats, the copper and brass pipes formerly used lost a large percentage of their strength. The change in the machinery of the new battle ships of the *Alabama* class, without hull changes, necessitates the reduction of the thickness of the shell plates for cylindrical boilers. In the *Alabama* class this thickness had reached $1\frac{7}{16}$ inches in material, having a tensile strength of over 65,000 pounds, an elastic limit of over 35,000 pounds and an elongation of 24 per cent. in 8 inches. Experiments have been made on a higher carbon steel, oil tempered and annealed, which has a tensile strength of over 74,000 pounds, an elastic limit of over 40,000 pounds, an elongation of over 21 per cent. and a very satisfactory cold-bending test. With the higher pressures called

for in the new battle ships, this steel would allow a slight reduction in thickness. With this high-grade boiler plate, nickel-steel bracing and rivets will be used.

The use of water-tube boilers is increasing in all foreign navies, and the experience of the last year would warrant us in using boilers of this type in all our ships, says Commodore Melville. That contracts for the new battle ships were awarded on the basis of cylindrical boilers is explained as follows: The Bureau designed and was anxious to use water-tube boilers; but, as it was decided that these ships should be practically identical with the *Alabama* class, without change in hulls, the use of the water-tube boilers would have involved a readjustment of hull weights to maintain the trim. But in the Department circular of July 26, asking for designs for higher speeds and greater endurance, builders were encouraged to use the water-tube boilers, as the easiest way to secure the desired results. The bids received on September 1 justify this idea, and it is practically certain that the new type of boiler will be used, and all machinery will be of the most modern type.

The experiments with liquid fuel, on the torpedo boat *Stiletto*, were very satisfactory, though the economy over coal was not high, owing to the fact that the machinery was not specially adapted to oil fuel. The oil used had a specific gravity of 0.85 to 0.87, a flash point of about 315 degrees Fahrenheit and a burning point of about 350 degrees Fahrenheit.

The repair ship *Vulcan*, fitted out during this war, did invaluable service. This ship arrived at Guantanamo on July 1, and by the end of August she had made repairs on 63 ships and had furnished supplies to 60 ships. The *Vulcan* was fitted with machine tools, cupola, forges, brass furnaces, etc., and carried a crew of 100 skilled mechanics. The usefulness of distilling ships was also proven in the war, though the two vessels thus equipped were not completed before active operations were over. It was shown that a multiple-effect evaporating machine could be made which would give 20 pounds of fresh water for every pound of coal burned in the boilers; and such a vessel could supply 50,000 to 60,000 gallons of water per day and carry 3,000

tons of coal, supplying a large number of tank vessels and serving as a collier in case coal was more useful than water. The Bureau deems a distilling ship of vital necessity for a fleet of any size; and the cost of thus supplying fresh water is very much less than the purchase of water under any except the most favorable circumstances. Moreover, fresh water is absolutely necessary for the integrity of water-tube boilers.

The report deals briefly with the performance of the battle ship *Oregon*. Between March 6 and May 24 this ship steamed over 14,500 miles, stopping only for coal, and not being delayed anywhere an hour through any derangement of the machinery. She stopped at Key West only for coal, and at once joined the blockading fleet ready for service. While this is an unparalleled record, the *Oregon* surpassed herself in the great battle of July 3. Always ready for service, she, on that day, speedily attained a power greater than that devoloped on her trial, and, notwithstanding her greater displacement and foul bottom, she reached a speed only slightly less than was then recorded.

The performance of the two 1,000-ton gunboats, *Annapolis* and *Marietta*, is also most favorably commented upon. Both of these ships have water-tube boilers, made by the Babcock and Wilcox Co., and both were commissioned in 1897 and have been over one year in service. The *Marietta* covered 13,000 miles at an average speed of 9.2 knots, and for several periods of about a week each the average was 10 knots. Yet, in both of these vessels the boilers are now in excellent condition and ready for any service.

The lessons of the war, for the steam engineering department, are summed up as follows: The necessity of frequent tests under working conditions of the machinery of all vessels in reserve. All naval stations should be in positions of strategic value, and be properly fitted for repairs and provided with adequate quantities of non-perishable stores. Key West is such a station. Fresh water is almost as important as coal, and distilling ships are a necessity. Every fleet should have a repair ship. With more than two main engines, there should be three engines driving three screws, and not two main engines on each shaft. At

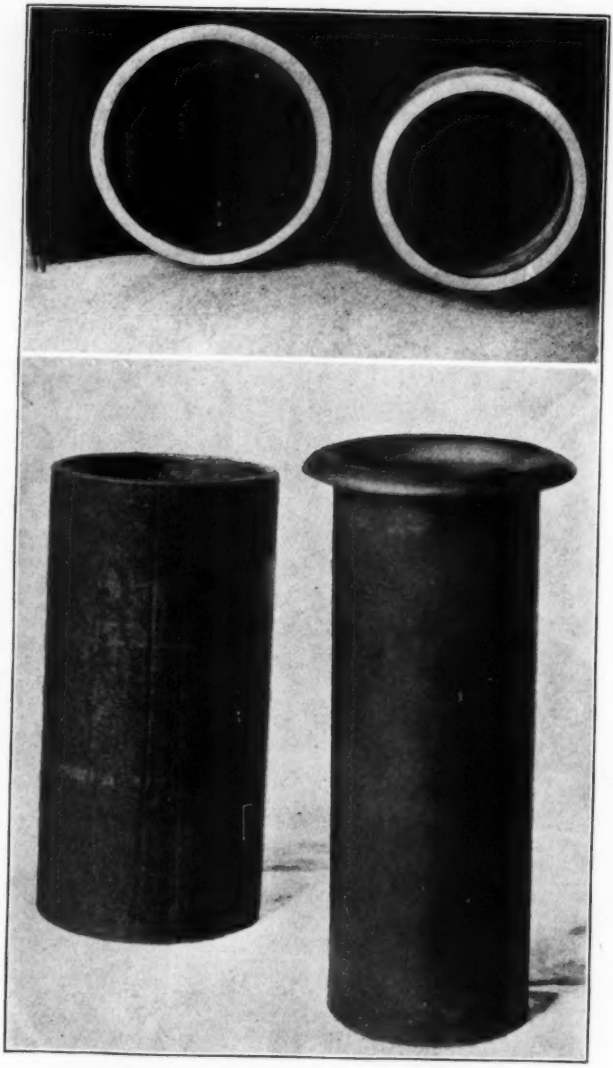
Santiago the *New York* and *Brooklyn* had their forward engines disconnected on July 3 and could not stop to couple them. An accident to any part of either of the two engines on a shaft disables half the power; in the three-screw ship this fraction would be only one-third.

There should be frequent trials under forced draft to keep the blowers in good condition and make the men familiar with working under maximum conditions. Until the day of the Santiago fight some of the ships had never been under forced draft since their trial trips. The position of these blowers is important, and they should not be put in pockets or corners in the fire rooms to make space for other equipment. In the *Cincinnati*, temperatures as high as 205 degrees Fahrenheit were noted in the fire rooms. The personnel must be regulated by the class of the ship, and there must be a reserve of trained men and officers; a war of long duration would have greatly embarrassed the Government owing to the difficulty of supplying the places of disabled or invalided men. Volunteers, however well trained in other ways, cannot replace the regular officers. Finally, our fighting ships must have the highest practicable speed, and 18 knots is now recognized as a standard in battle ship construction.

SOLID-DRAWN BOILER TUBES.

When one considers the fact that the failure of a single tube in a high-pressure boiler on board ship may either lead to disaster or so greatly affect the conditions of the moment as to turn success into failure, one is forced to look more closely at these tubes and hail with gratification every step taken towards their perfection. The day has passed when a "pretty fair tube" or a "good lot of tubes" will satisfy the demands. Increase of pressures brings with it a requirement of uniformity in boiler tubes never before thought possible. Each individual tube must be as nearly perfect as can be made in order that the life of the boiler may be fairly gaged and the "weak member," if possible, eliminated.

Heretofore, in modern marine boilers, of the fire-tube variety,



LAP WELDED. SOLID DRAWN.

BOILER TUBES.

the life of a set of steel tubes of No. 12 B.W.G. was placed at about four years. Recently, with a view to extending this, the gage has been increased to No. 9, B.W.G. adding weight to the plant, of course, but giving commensurate benefits. Still with lap-welded tubes, lack of absolute uniformity will always exist, no matter how close the inspection, and when tubes begin to "go" here and there through the weakest points, the troubles begin.

Many tube failures occur through pitting, due to the dislocation, after a few months' use, of mill scale, or some other dirt, rolled into the tube surface and which has escaped the inspector's eye. This dislodged, leaves perhaps but a paper thickness to that spot, which soon corrodes through, the pit forming a cup for moisture, even when the boilers are "dried out." Again, failure occurs after a year or two of use, due to the general corrosion affecting the thin side of a tube non-uniform in gage, or perhaps in rolling out a leaky tube of this kind the expander brings the thin side to such a degree of attenuation as to render the general corrosion or waste sufficient to penetrate the metal.

In these particulars at least we find the solid-drawn steel tube appeals to the engineer most forcibly. The process of manufacture eliminates at least the danger from either defects in surface or non-uniformity in gage. Besides this it brings to us a surface that is about as nearly perfect as possible. Engineers need not be reminded of the advantages of such surfaces: less likelihood of having tenacious deposits, less work in removal of scale if it does appear, and a guarantee of a *uniform* deterioration if half decent care is given the boiler.

The photograph here given shows most graphically the difference, both in surface and gage, between a solid-drawn steel tube and an ordinary lap welded one. The photograph was taken by the writer from samples at the Bureau, and while, of course, the best obtainable lap-welded tube was not used for the illustration, it shows simply what does occur at times, in the manufacture of this kind of tube, and on the other hand gives a specimen of a soild drawn tube which can be produced with unvarying uniformity.—(Ed.)

THE FUTURE OF MARITIME COMMERCE.

The "Engineering Gazette" recently summarized as follows: A paper by Mr. Elmer L. Corthell, D. Sc., read before the American Association for the Advancement of Science. It was entitled "Maritime Commerce: Past, Present, Future."—The main purpose of the paper was to furnish reliable data for an opinion as to the future requirements in regard to the depth and other dimensions of channels in the ports of the world, in order that the authorities concerned might know what they have before them in the way of harbor improvements. For the purposes of his paper, the author made elaborate investigations over a period of seven years, with the following deductions: The average length of the 20 largest steamships, which was 230 feet in 1848, will be 765 feet in 1923 and 1,000 feet in 1948. The breadth will increase from 36.2 feet in 1848 to 80 feet in 1923 and 100 feet in 1948. The depth will increase from 23 feet in 1848 to 41 feet in 1923 and 43 feet in 1948. The loaded draught will increase from 19 feet in 1848 to 31 feet in 1923 and 33 feet in 1948. The speed will increase from 9.2 knots in 1848 to 21 knots in 1923 and 24 knots in 1948. The tonnage will increase from 1,430 in 1848 to 24,000 in 1923 and 30,000 in 1948. The number of graving docks 500 feet long and over will increase from 23 in 1881 to 176 in 1948. The speed of the fastest steamships will increase from 10 knots in 1848 to 30 knots in 1948, The total number of sailing ships will decrease from 56,281 in 1873 to 10,800 in 1948. The total sailing tonnage will decrease in the same period from 14,185,836 to 3,241,000. The average tonnage of sailing vessels in the same period will remain practically stationary, being 252 in 1873 and 300 in 1948. The total number of steamships will increase from 242 in 1848 to 16,685 in 1948. The total tonnage of steamships will increase from 74,700 in 1848 to 45,000,000 in 1948. The average tonnage of steamships will have increased in this period from 310 to 2,700. The total effective carrying power of steam and sail will have increased in the period from 16,500,000 tons to over 138,000,000 tons. The weight of sea-borne commerce will have increased in the period from 26,500,000 tons to 435,000,000 tons.

Mr. Corthell is a great advocate for harbors, canals and channels being made of increased depth, and asserts that if the depths through outlying bars, in river channels, into basins and docks, and alongside wharves and quays, are not increased, the size of steamships will not much further increase, and if it does not, he continues, the limit is in sight to the carrying power and the economies of commerce. This matter is not, however, being overlooked, and in reply to the question, "What is the engineer doing to meet the desired increase in the draught of steam ships?" the author answers that no port of the world will, in the near future, be classed or used as a first-class port which will not readily admit steamers drawing at least 30 feet of water. This means, he adds, 35 feet in the entrance channels, through sea bars; 32 feet in river channels and other entrance approaches, and basins, and along the quays and wharves. What is being done to secure these depths? "First and most important, the Suez Canal, which was built with a depth of 26 feet, is now nearly deepened to 28½ feet, and the International Engineering Commission has made plans for the next deepening to 9 meters—practically 30 feet. The Amsterdam Canal, opened with only 23 feet, is nearly deepened to 30 feet. The new Kaiser Wilhelm Canal has nearly 30 feet. Liverpool has now an entrance channel of practically over 30 feet at low tide—27 feet to 57 feet. Southampton has 30 feet at low tide. New York will have by the present plans 35 feet at low tide, Boston will have 30 feet at low tide, Philadelphia the same. New Orleans, in the plans for an enlarged channel way, will propose to the United States Government a minimum depth on the sea bar of 35 feet, and at least 32 feet in the South-West Pass and Mississippi River. Galveston, by the present plans now being carried out, will have 30 feet. Hamburg will, in the near future, have a deep channel way to the sea adequate for the largest vessels. Antwerp has a sea entrance 30 feet deep, a river depth of 31 feet at high water, and a projected depth of port area of 32½ feet. Other ports might be mentioned where deeper channels are in progress of construction or are projected. Liverpool is being improved beyond all other ports of the world, and is expending immense sums to pro-

vide for the steamships of the future. It is widening and deepening the docks to accommodate vessels up to 900 feet in length and to 90 feet beam and 36 feet draught. It is building a dry dock for vessels of this class, and is making plans for one 1,000 feet long. At London the vexatious bars and tortuous channels near the mouth of the Thames, through which it is dangerous in certain stages of tide, and in fog, to navigate vessels drawing over 26 feet, are to be removed and improved, and a navigable depth of 30 feet provided."

THE NEW DRY DOCK BEING BUILT AT NEWPORT NEWS.

The Newport News Shipbuilding and Dry Dock Company recently began work upon the new dry dock "No. 2" of which the dimensions finally decided upon are as follows:

Clear length inside the caisson, 806 feet; breadth on bottom, 80 feet; breadth at top, 162 feet; entrance constructed so as to admit any vessel that can be accommodated inside the dock. Depth over the sill, 30 feet, at mean high water. Mean range of the tide, 2.6 feet.

The entrance abutments will be constructed of concrete faced with granite. The bottom of the dock will be of concrete over piling. The interior will be constructed of timber. The caisson will be constructed of steel, and it will be operated with trimming tanks so arranged that it will not be necessary to pump out the water ballast. The pumping plant has been designed to empty the dock in two hours, which is at the rate of about 200,000 gallons per minute.

There are two centrifugal pumps for emptying the dock, each pump having a suction and discharge area equivalent to 58 inches in diameter. Each pump is driven by a compound steeple engine, having cylinders 21 inches and 42 inches by 30 inches stroke.

There is also a drainage pump having a suction and discharge of 18 inches diameter, driven by a 15-inch by 15-inch engine. All of these pumps are designed to work at 125 pounds steam pressure.

Two first-class battle ships can be repaired in this dock at one

time, or the largest ocean liner now contemplated will have plenty of room to spare.

It is not the intention to use a traveling crane in connection with this new dock, experience at these works showing but little advantage accruing from having heavy traveling derricks for general repair work. There will be, however, four stationary derricks placed at or near the corners of the dock, each having a capacity of about 30 tons, and these will probably be operated by electricity.

ENGINE FAILURES.

Mr. Michael Longridge's last report to the Engine, Boiler and Employers' Liability Insurance Company, Limited, contains, as his reports invariably do, much important information as to the pathology of steam engines and boilers, and is well worthy of study. The company's record of accidents for the last twelve months is below the average, but the gain in this direction is offset by the greater gravity of those that did occur. Several factors contribute to this result. The continuous improvement in knowledge of design, and in perfection of workmanship, naturally tend to diminish the frequency of accidents, though defects in these two matters are still responsible for 36 per cent. of the total breakdowns occurring. Of the remainder, 25 per cent. arose from the negligence of owners or attendants, thus making the human element responsible for 61 per cent. of the total accidents arising.

To offset the gain due to the better design and workmanship put into modern engines, we have a greater cost of repairs when necessary, owing to the large size of the parts in use, and the expensive workmanship put into them. Perhaps some of this increase in the repair bill should also be credited to the higher speeds now adopted. At one extreme we have a beam-pumping engine making eight to sixteen strokes a minute, and at the other an inclosed electric-light engine running at perhaps 450 revolutions per minute. In a former case a small break can be seen and attended to before it becomes serious, whilst if anything goes in the latter case there may be a general wreck before the attendant has a chance to find out that anything is wrong. In fact, the

precautions necessary to enable engines to run successfully at such speeds were not learnt without many breakdowns, which acted as danger posts to warn designers of what it was necessary to avoid, and though the ability to do this work is now by no means rare, it was only acquired at the expense of many anxious years of experience on the part of the pioneers who broke the way for the rest.

The following list shows the nature of the accidents which have occurred to the engines under Mr. Longridge's supervision during the past year and during the previous fifteen years.

NUMBERS.

	During 1897.	During previous 15 years.	Total.
Valves and valve gear	28	395	423
Spur gearing	18	390	408
Air-pump motions	19	232	251
Air-pump buckets and valves	3	185	188
Columns, entablatures, bedplates, and pedestals	10	164	174
Bolts, screws, gibs and cotters	4	141	145
Parallel motions, links and guides	3	119	122
Main shafts	8	109	117
Cylinders, valve chests and covers	15	68	83
Pistons	3	55	58
Governor gear	9	50	59
Piston-rod crossheads	5	46	51
Piston rods	5	42	47
Flywheels	1	44	45
Air pumps and condensers	5	37	42
Connecting rods	7	37	34
Cranks	1	32	33
Crankpins	5	25	30
Gudgeons in beams	1	24	25
Beams and side levers	3	18	21
Total wrecks, cause unknown	...	6	6
Second-motion shafts	...	3	3
Main driving ropes and belts	1	2	3
	154	2,214	2,368

It will be noted that breakages of cylinders, valve chests and covers are relatively more numerous than in previous years. This is mainly due to the recent increase of steam pressures, and the inadequacy of the flat surfaces used to resist them. A

number of the condenser failures are also due to the use of flat surfaces of insufficient strength. As shown by Mr. Longridge's experiments recorded in his report last year, many condensers made in one with a horizontal air pump are exposed to very considerable pressures, due in part to contracted valve openings and to the inertia of the water pumped. This year's experience confirms the necessity of having ample strength in the flat sides of condensers of this type.

As regards the flat surfaces exposed to high steam pressures, it may be stated that calculation is, in such cases, often only a very imperfect guide. The complete theory of the strength of such surfaces is so complicated as to make it impracticable to apply it in its entirety, particularly when stiffening ribs are used. There can be little doubt that in many instances these latter are in themselves a source of weakness, particularly when a plate is exposed to wide ranges of pressure. With a steady load, they are not likely to do any harm, apart from the possibility of contraction strains in the casting. When, however, the load is a variable or alternating one, stiffening ribs should be used with caution, as otherwise they may actually diminish the elastic strength of the plate. As a guide, to be used, of course, with judgment, Mr. Longridge proposes that flat surfaces should have a thickness given by the expression

$$\text{Working pressure (pounds per square inch)} = \frac{40\,t^2\left(1+\left(\frac{B}{L}\right)^4\right)}{B^2},$$

t being the thickness in sixteenths of an inch, and B and L the length and breadth of the plate in inches.

An instance of how a comparatively trifling omission on the designer's part may cause a general wreck is well illustrated by one of the accidents reported by Mr. Longridge. The small nut at the back of the lever on a Corliss valve spindle securing the pin to which the dashpot rod was fastened, dropped off. As a result the valve failed to close when released by the governor. The speed rapidly increased, and before the engine driver could shut off steam the flywheel burst, wrecking the engine house, and doing other damage.

A very important part of the work of Mr. Longridge's company is the inspection of boilers, but it would seem that their reports thereon are not always received in a friendly spirit by the owners. Many of these boilers are bought second hand from brokers, and after the transaction is concluded the purchaser thinks it well to have the boiler examined. In one case the inspector found that the shell of the vertical boiler below the mudholes was as thin as tinplate, and even perforated in parts, the openings being stopped by cement. On appeal the brokers' foreman argued that "there was very little pressure at this part of the boiler," and recommended more cement. In another case the purchase was effected subject to the boiler being approved by the company. On examination the boiler was found to be corroded through, and, to the great disgust and indignation of the vendor, the buyer refused accordingly to complete the purchase, in spite of offers from the former "to guarantee the boiler against anything."

During the year Mr. Longridge has made a number of experiments on the strength of boiler flues, which are of importance in showing the loss of strength which may arise from even a slight departure from the circular form. The flue tested was 18 feet 6 inches long and about 33 inches in diameter. It was built up of six rings of $\frac{3}{8}$-inch iron plates, lap-jointed and single riveted. Careful measurement showed it to be about $\frac{3}{8}$-inch oval. Under pressure it showed signs of collapse at 110 pounds per square inch. On releasing the pressure the flue was found to be now $1\frac{5}{16}$ oval, and on again testing collapse commenced at 60 pounds per square inch. From further tests on another flue the conclusion was reached that if perfectly circular the collapsing pressure of the flue would have been 150 pounds per square inch.—"Enginering."

THE STEAM TURBINE IN ENGLAND.

In noting the following interesting extract from an English newspaper, furnished by Consul Metcalf, we would state that further information in regard to the new turbine destroyers gives as a clause in the contract a guaranteed speed of 17 knots per

hour when *backing*, being slightly less than half the speed going ahead.—(Ed.)

THE PARSONS STEAM TURBINE WORKS.

We understand the new works of the Parsons Steam Turbine Company at Wallsend-on-Tyne are now complete, and the manufacture of patent steam turbines, similar to those which have driven the now famous *Turbinia* at such an unprecedented speed, has practically commenced. The works cover about 11½ acres and contain three rows of well-equipped fitting and machine shops, space for several berths, and a fine block of drawing and commercial offices. The company which took over Mr. Parsons' patent and furnished a capital of £200,000 to carry on the enterprize was formed in August of last year, and, in the September following, received its first order—from a foreign government for a torpedo-boat destroyer of about 200 feet long, to have turbine engines of 10,000 horse power. In March this year, the company received its second commission, this time from the British admiralty, for a vessel of similar size and type. Work on both these vessels and their machinery has now commenced—the hulls at a local ship yard and the turbine engines at the new works—and the first one is expected to be ready for launching before the year closes. Other orders, we hear, have since been booked, and the new works are starting with every prospect of prosperity from the very beginning.

That there is a great future before the steam turbine, no one now doubts. The advantages of the turbine over the ordinary marine engine are so pronounced in the way of space, weight and speed, that many engineers do not hesitate to describe it as one of the leading inventions of the century, which is destined to revolutionize marine propulsion and inaugurate a complete change in the shipbuilding and shipping trades—a change that may not improbably be as great in its way as the substitution of steam for sail shipping. For speed there is certainly nothing afloat that can touch the *Turbinia*. The tremendous impression that this little craft made at the great naval review last year is still fresh in the public memory, but she has since improved upon this; and on some of the private runs she has latterly taken off the Tyne she

has easily attained 35 knots, and the *Turbinia* is only a small experimental launch of 100 feet in length and weighing 45½ tons, all told. With a longer and a bigger vessel, it is reasonable to assume that a greater speed still can be attained, and Mr. Parsons himself entertains no doubt that a vessel can be built to steam at 40 knots. As the destroyers this new company is now building are twice the length and six times the weight of the *Turbinia*, and will have engines of five times the *Turbinia's* horse power, it will be interesting to note by how much they will exceed the *Turbinia's* speed. As a matter of fact, the two destroyers now building are guaranteed to produce a minimum speed of 35 knots; but as they will embody many improvements which Mr. Parsons has been able to evolve during his experiences with the *Turbinia*, and are to be much larger and more powerful, we understand that there are reasonable expectations of attaining 40 knots.

But speed, after all, is only one of the advantages of the steam turbine. It occupies much less space in the hull, since the steam acts direct upon the turbines, and the ordinary cylinders, cranks and shafts are dispensed with, and consequently saves enormously in weight and space of machinery. And, no less important, it burns much less coal in proportion to the speed it develops. Such a high speed as 35 knots inevitably means forced draft and heavy coal consumption, but even the little "*Turb*" saves 15 per cent. of coal traveling at ordinary accepted rates, and the saving would be greater in larger vessels. Less coal means less bunker space and more carrying capacity; indeed, apart from increased speed, the strong point about the steam turbine is the small space and weight it occupies in the hull, as compared with the existing triple-expansion machinery, which is a consideration that may in time lead to its adoption in the ordinary tramp of commerce, though for the present the steam turbine will no doubt be mainly utilized for destroyers, cruisers and passenger vessels. Another point to be noted is the absence of vibration. This, as marine engineers and naval architects know full well, is the curse of high-speed steamers, and is well-nigh incurable by any means whatsoever. It may be unpleasant to be on the *Turbinia's* deck when she is traveling at 35 knots and cutting the water like a

knife, but there is no torturing vibration such as is experienced in an Atlantic greyhound, and still more in the present-day torpedo destroyer. And, finally, it needs to be said, in order to remove a common misapprehension, that the steam turbine can be stopped and reversed with even greater facility than the twin-screw engine. The inventor has worked at this problem for years, and he has succeeded so well that the *Turbinia* can be handled at will with absolute precision. She can be brought to a standstill within forty seconds, for one of the propellers on the center shaft is used solely for reversing, and can be set in operation by the reversing gear even before steam is shut off on the driving propellers, and, furthermore, having three shafts, by shutting off steam on one shaft and keeping the other at work while using the reversing propeller, she can be quickly turned and handled in any direction while going at full speed.

SHIPBUILDING AT NAGASAKI.

The most important private dock and shipbuilding yard in Japan is that at Nagasaki, owned by the Mitsu Bishi Kaisha, and the work done in it may be taken as representative of the best work of the kind done in Japan. It will, therefore, no doubt, interest some of our readers to note some of the points which appear in a report which was recently issued describing the extent of the establishment and the nature and amount of the work. Before the opening of Japan to foreign trade, Nagasaki was the only point of contact with the outside world, and it was here that some of the first experiments were made in Western methods, and among others, attempts at engineering. About forty years ago, a small mechanical engineering works was started under the Shogunate, and a few engines were actually made from drawings obtained from books, with such assistance as could be got from the Dutchmen, who were the only foreigners allowed to land in the country, and even they were restricted within very narrow limits. Ten years later the works passed into the hands of the Imperial Government, and were greatly extended under the superintend-

ence of British engineers and shipbuilders, and supplied with a good selection of engineering and shipbuilding machine tools. A graving dock capable of accommodating the largest merchant steamers was constructed, and very soon the establishment obtained a high reputation for its work, and was much taken advantage of by vessels of every description and nationality, from ironclad cruisers of the first class down to coasters, and many small steamers for the coasting trade of Japan were built and completed with engines, boilers, and all fittings. In 1884 the establishment passed into the hands of its present proprietors, "The Mitsu Bishi Company," and the developing mercantile marine in Japan has caused huge additions to be made to the works. The large dock built by the Government has been lengthened and another smaller one added. Very great improvements have been, and are now being, made in the works, and almost all the machinery has been modernized and largely added to, both in the engine works and shipbuilding yard, so as to enable the heaviest work to be undertaken. The boiler-making and moulding shops are now equipped to meet any requirement, so that perhaps, taken as a whole, the works have the heaviest and most complete plant required for marine engineering and shipbuilding purposes to be found in the East.

The docks, built of granite, can take vessels of any size up to 510 feet in length, and at ordinary spring tides the water on the blocks of the huge dock registers 26 feet 6 inches, and on those of the smaller one 22 feet, the widths being equal to anything up to 80 feet and 53 feet respectively. There is also a slip capable of lifting vessels of 1,200 tons register, which has been found to be a most useful addition to the yard. Railways have been laid throughout the works, a locomotive crane has been got for the shipyard, and the usual complement of hydraulic gear, electric drills and heavy bending, shearing, punching and drilling machines, as well as sheer legs capable of lifting 80 tons. Attached to the yard there are rigging and sail-making lofts, and the company has powerful salvage plant, ready at short notice for the assistance of vessels in distress. Iron shipbuilding was commenced in 1889 by the building of a steamer of about 200 tons

register for the company's own use, followed by two or three of similar design, but of increased size and power. Gradually others of larger size were attempted, and at the present there are four vessels on the stocks, one 300 feet long and 2,530 tonnage, two 445 feet long and 6,550 tonnage, and a fourth 238 feet long and 1,540 tonnage. The harbor of Nagasaki is one of the finest in the world and is much resorted to by the fleets of all nations, and the engine shops and shipbuilding yards are found very convenient for repairs. An understanding with Japan would, therefore, not only be a most important factor in any complications which might arise in the Far East, not only on account of the strength of her navy, but also for the facilities she could offer for repairs and coaling. As at present practically all the iron and steel used in the construction of the ships requires to be imported, British shipbuilders need not be very much afraid of competition. It would, however, be interesting if returns were published showing the cost of the vessels constructed, compared with what they would have cost if they had been built in Europe.—"Engineering."

IMPROVEMENTS IN THE BIG SHIP YARDS.

Not only has the arousal of activity in the shipbuilding industry resulted in the establishment in this country of several new shipbuilding plants of considerable magnitude, but in many cases the older institutions have made arrangements to expend large sums for new and improved machinery. The Brown Hoisting and Conveying Machine Co., of Cleveland, has closed contracts with both the William Cramp & Sons Ship and Engine Building Co., of Philadelphia, and the Newport News Shipbuilding and Dry Dock Co., of Newport News, Va., for cantilever cranes of great capacity.

These electric traveling cantilever cranes will be practical duplicates and of 15 tons capacity. The length of the crane will be 180 feet over all; the arms will be 32 feet above the trestle, and the trestle 70 feet in height. It may thus be readily seen that the trestle and crane will bring the horizontal boom of the crane high enough above the pair of ship ways between which it will

be erected to enable it to pass over the highest point of the ships under construction. The arms of the cantilever will, of course, project over the full width of the ships on either side of the trestle. It will be possible with these new cranes to simultaneously hoist the material, move it backward or forward on the arm, and at the same time have the whole structure travel along the trestle. The speed in the movement along the trestle will range from 400 to 700 feet per minute, and the speed in hoisting will vary from 150 to 300 feet per minute.

The crane just ordered by the Cramps is the first crane to be built by the Brown Company for the Philadelphia yard, but it is the fourth furnished to the Newport News works, and is practically a duplicate of its predecessors, except in the matter of minor improvements. In illustration of the degree of development attained by these machines, it may be mentioned that when the first crane furnished to the Newport News company placed 750 feet of plate girders on the ways in four and one-half hours it was regarded in shipbuilding circles everywhere as a remarkable achievement, but the demands of a wooden shipyard have so increased since that time that the Newport News company asked for a crane that could run 600 feet per minute with a load of 12½ tons. Now the Brown company is to go further and furnish a crane of 15 instead of 12½ tons capacity and of 700 instead of 600 feet maximum speed per minute.

The Cramps are also considering the advisability of further adding to the equipment of labor-saving machinery at their plant, and there is every probability that the Brown company will secure the contract. The Cleveland concern recently also made an outright sale of one of the cranes above described to a large German concern.

An order that will necessitate the manufacture of an entirely new machine is from the Pennsylvania Steel Co. of Steelton, Pa., for an electric bridge tramway for handling rails. This tramway will be 170 feet in length and 30 feet in height and will have two parallel tracks and trolleys, thus enabling the rails to be suspended firmly and evenly instead of swinging from side to side. The Brown company some years ago built a similar tramway

for the Lorain Steel Co., of Lorain, O., but it was of the single-trolley type.—"Marine Review."

A SCHEME FOR THE RAPID ANALYSIS OF BOILER WATERS FOR SCALE-FORMING INGREDIENTS.

The complete analysis of a boiler water presents no difficulties to the analytical chemist, but the time required for the various separations and determinations of the constituents therein often precludes many examinations. Where the chemical analysis is desired for the amounts of the scale-forming ingredients only, a method should be used that is relatively rapid and approximately correct. A scheme embodying such a method whereby the amounts of calcium carbonate, calcium sulphate, magnesium carbonate and iron oxide could be rapidly determined, would be of great service in technical laboratories. In many railroad laboratories the following process is used to determine *total* scale-forming ingredients.

One-half liter of the boiler water is evaporated to dryness in a weighed platinum dish and the amount of residue determined.

This residue is treated with a solution of alcohol 50 parts, and water 50 parts, and then filtered.

The undissolved matter is designated as scale-forming material.

This method gives, of course, the *total* matter that is scale forming, but does not indicate the proportions of each constituent.

It is essential to know, in many cases, whether the scale will be calcium sulphate or calcium carbonate or magnesium carbonate.

The scale formed by calcium sulphate is hard, compact and exceedingly difficult of removal, whereas the scale formed by calcium and magnesium carbonates is more or less porous and not difficult of removal.

A scheme of analysis, that has been used by the author, and showing many advantages for correct determinations with rapidity, is here given in tabular form.

SCHEME FOR RAPID ANALYSIS OF BOILER WATERS.*

Total solids. / **Mineral matter.** / **Organic matter.**

The desired amount of water is evaporated to dryness in a platinum dish and weighed. This residue (1) represents total solids. Ignite, then moisten slightly with distilled water, place in an atmosphere of carbonic acid for half an hour, dry and weigh. This residue (2) is the total mineral matter combined with carbonic acid, as it previously existed, before ignition. The difference in weight between residue (1) and residue (2) is the organic matter.

Scale-forming ingredients.

Extract soluble matter from residue (2) with successive small portions of distilled water, in all, 50 c.c. or less. Filter through ashless filter; dry the residue adhering to platinum dish. Dry and ignite filter and return the matter, it may have retained, to the platinum dish and weigh. The weight of this residue (3), represents the total scale-forming ingredients of the water.

Non-scale-forming ingredients.

The filtrate contains the alkalies and magnesia combined with sulphuric acid and chlorine. These may be determined, if desired, but are not necessary in this operation. Their aggregate weight may be determined by subtracting residue (3) from residue (2).

Treat residue (3) with hot HCl and filter. Wash well.

RESIDUE. Insoluble mineral matter. Dry, ignite and weigh as such. SiO_2 etc.

FILTRATE. Add ammonic hydrate in slight excess, boil and filter.

RESIDUE. $Al_2O_3 . Fe_2O_3$ Dry, ignite and weigh as such.

FILTRATE. Add solution of ammonic oxalate in slight excess, set aside ½ hour. Wash with water containing ⅛ its volume of ammonic hydrate.

RESIDUE. Dry, ignite and weigh as CaO

FILTRATE. Add solution of sodic phosphate with constant stirring. Set aside ½ hour. Filter. Wash with water containing ⅛ its volume of ammonic hydrate.

RESIDUE. Dry, ignite and weigh as $Mg_2P_2O_7$ and calculate to MgO

FILTRATE. Acidify with HCl, add solution of $BaCl_2$ in slight excess, boil, set aside ½ hour, filter, wash well with hot water.

RESIDUE. $BaSO_4$, dry, ignite and weigh as $BaSO_4$, and calculate to SO_3. This amount of SO_3 is combined with CaO to form $CaSO_4$ that exists in residue (3).

SiO_2 etc.	$Al_2O_3 . Fe_2O_3$	CaO	MgO	SO_3

*Communicated to the writer by Prof. Wm. Main, Chemical Expert to New York Filter Co.

The remaining CaO, as well as the MgO are calculated to carbonates and the amounts of $CaSO_4$, $CaCO_3$, $MgCO_3$, SiO_2, etc., and $Al_2O_3.Fe_2O_3$, should equal the weight of residue (3). Professor Main states regarding the above scheme, as follows:

Careful tests made with artificial mixtures of sulphate of lime and carbonate of lime show that the error due to solubility of calcium sulphate, in water, is hardly weighable, especially after it is converted into anhydrous sulphate by heat.

The amount of sulphate of lime which will fail to precipitate from solution and that which can be dissolved (in any reasonable time) from the solid state, with pure water alone, are very different things. This supposed solubility has previously prevented chemists from using methods similar to the above scheme for a rapid method of boiler-water analysis.—Thos. B. Stillman in "Stevens Indicator" for October.

AIR CHAMBERS ON LONG SUCTION PIPES FOR STEAM PUMPS.

We have received the following letter: "We are changing the suction pipe on a 'Hooker' pump having 12-inch stroke, 6-inch diameter water cylinder. The new pipe is to be 6 inches in diameter, 2,100 feet long, with a lift of about 8 feet, the pipe running nearly level until within 100 feet of the pump. Having had little experience with long suction pipes we are inclined to doubt the practicability of the scheme, and would like to know if an air chamber on the suction pipe near the pump would be advantageous. If so, please explain its action."

Such a suction pipe can be made to work satisfactorily, but it must be remembered that the moving column of water in the pipe, even though moving at no great speed, will have considerable dynamic energy, and that if it is attempted to stop it or even to check its flow suddenly, serious water hammer will result. To avoid this water hammer an air chamber must be used, and it is important that this chamber should be properly located, and many air chambers on suction pipes are not properly located. Experience proves that the water passing under or past the opening of the air chamber in a line at right angles to it will

pound about as much as though no air chamber were there, and in arranging air chambers they must be so located that the energy of the blow delivered by the column of water can be expended directly upon the confined air cushion. Mr. F. Merriam Wheeler, in discussing this matter at a meeting of the American Society of Mechanical Engineers, November, 1892, called attention to some common errors of arrangement, and showed by sketches proper and improper methods of arrangement. Generalizing, we may say that the proper method consists in so placing the air chamber that whenever the column of water is stopped or checked by the action of the pump it can flow on past the suction chamber or suction valves in a straight line to the air chamber. Bad arrangements are those in which the checked column of water cannot do this, but must stop and turn a sharp angle to enter the air chamber. Fig. 1 is given by Mr. Wheeler as a wrong arrangement, while Figs. 2, 3 and 4 are good arrangements.

Mr. Wheeler is a strong believer in the air chamber for the suction, and, when the head pumped against is not high, says that an air chamber on the suction is more important than on the delivery.

To show the importance of the suction air chamber, the Geo. F. Blake Manufacturing Company, with which company Mr. Wheeler is connected, have, at their New York office, one of their "Simplex Compound" pumps with water end $2\frac{3}{4}$ inches diameter, 7 inches stroke, suction nozzle 2 inches, discharge $1\frac{1}{2}$ inches and with steam cylinder (tandem) $4\frac{1}{2}$ and $6\frac{1}{2}$ inches diameter. This pump is supplied with steam and draws water from an open tank in the cellar, discharging it through a pipe which can be throttled to give any desired pressure of delivery. Between the suction pipe and the suction air chamber is a throttle valve by which the air chamber can be cut off or connected at will. In a test made a few days ago to show the writer the effects of a suction air chamber on this pump, it was run without the suction air chamber, and, making 120 single strokes per minute, the pump ran quietly, but when speeded up to 160 single strokes the water hammer was very violent, making it evident

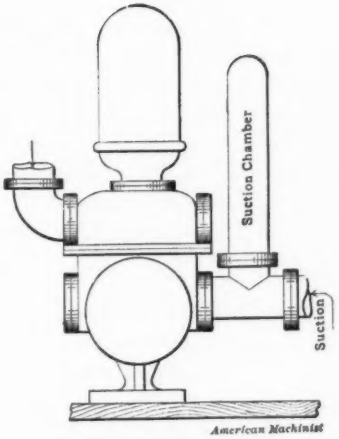


Fig. 1

IMPROPERLY ARRANGED AIR CHAMBER.

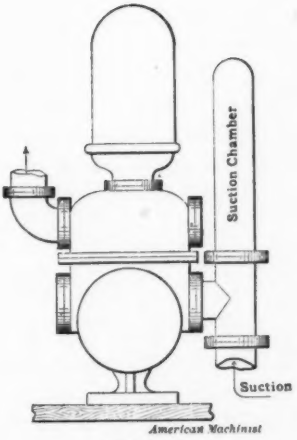


Fig. 2

PROPERLY ARRANGED AIR CHAMBER.

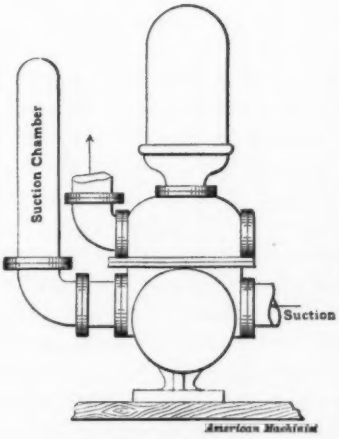


Fig. 3

PROPERLY ARRANGED AIR CHAMBER.

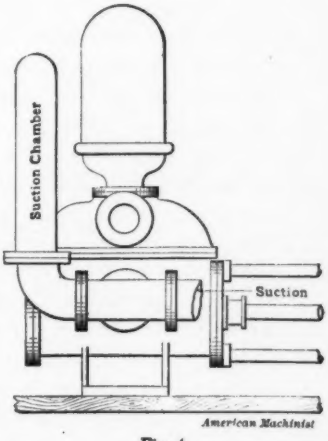


Fig. 4

PROPERLY ARRANGED AIR CHAMBER.

that a greater speed under those conditions would be inadmissible. Without any other change, the suction air chamber was then thrown in by opening the valve mentioned above, when the pump immediately ran absolutely without hammer, and the speed being then increased to 200, and finally 240 single strokes per minute, the pump still ran without signs of water hammer. There can be no doubt that many cases of persistent hammering would be entirely relieved by proper attention to this matter of suction air chambers.—"American Machinist."

ENGINES OF THIRTEEN HUNDRED SHIPS.

For nearly two years past surveyors in the office of Walter Miller, marine engineer of Cleveland, have been engaged in examining and reporting upon the engines of some 1,300 lake steamers for the "Great Lakes Register" of Chicago. Mr. John N. Coffin, who has been associated with Mr. Miller in the management of what is known as the machinery department of the "Register," has just prepared a most interesting summary of the results of this work. It is embodied in a paper read before the Engineers' Club of Cleveland, the paper also containing a synopsis of the rules compiled by the "Register" for construction of machinery in future. The summary of results of the "Register" work is given herewith.

Of the 1,300 odd vessels surveyed, says Mr. Coffin, we have found 1,150 to be screw propellers, and a trifle over 50 to be paddle or side-wheel propellers, the balance being schooners or tow barges, which were equipped with boilers and steam pumps, or hoisting or steering machinery. Of those fitted with screw propellers, we have found that 960 had solid cast wheels, 6 of them being of bronze, 8 of steel and 946 of cast iron; 185 had sectional wheels, one of them being of bronze, 6 steel and 178 cast iron. Of the entire number, 1,060 of these propeller wheels were fitted on the tail shafts with straight bore and key, while only 74 were fitted on a taper end with feather and nut, the latter arrangement being more modern practice and considered by most engineers to-day to be the preferable way of fitting propellers on the shafts. Of the paddle wheels we have found 23 to be fitted with feathering floats and 29 to have solid floats.

TABLE SHOWING TYPES OF ENGINES AND BOILERS BUILT FOR LAKE VESSELS DURING TEN-YEAR PERIODS SINCE 1860—ALSO RATINGS IN "GREAT LAKES REGISTER" GIVEN TO VESSELS BUILT WITHIN SIMILAR PERIODS.

	1860–1869	1870–1879	1880–1889	1890–1898
ENGINES:				
H.P. non-condensing	40	93	185	93
H.P. condensing	6	10	5	4
Steeple compound	22	62	89	39
F. & A. compound	5	12	154	99
Triple expansion	...	...	67	147
Quadruple expansion	...	...	1	6
Walking beams	8	10	8	7
Inclined and horizontal	1	2	7	9
BOILERS:				
Firebox	18	97	392	224
Scotch	1	8	193	348
Water tube	...	1	...	35
PRESSURES:				
Below 50 lbs.	5	3	2	3
Above 50 and below 75 lbs.	4	19	23	10
Above 75 and below 100 lbs.	5	59	122	29
Above 100 and below 125 lbs.	1	25	318	173
Above 125 and below 150 lbs.	...	3	52	184
Above 150 and below 175 lbs.	...	1	70	161
Above 175 and below 200 lbs.	...	...	...	19
Above 200 and below 225 lbs.	...	1	1	12
225 lbs	...	...	...	2
250 lbs	...	...	...	12
265 lbs	...	...	...	2
300 lbs	...	...	...	1
RATINGS:				
50	3	4	4	2
55	2	3	2	4
60	5	11	11	2
65	4	10	16	7
70	2	18	27	6
75	2	19	58	23
80	1	25	78	40
85	1	18	88	54
90	...	9	138	119
95	...	5	87	124
100	...	...	62	223

Referring to the table of engines, which is presented herewith, you will note some very interesting data relative to the advent and growth in favor of the different types of engines. For instance, you will note that the H.P. non-condensing engine, our earliest type, held the supremacy in numbers up to the end of the decade 1880 to 1890; this is accounted for in some degree,

during the latter part of this period, by the fact that there were many small boats and tugs built. The H.P. condensing engine cuts very little figure on the lakes, there being a total of only 25 in existence. The steeple-compound engine had an early start, 22 of them, now in existence, having been built earlier than 1870, 62 during the next 10 years, and 89 during the period from 1880 to 1890. This type then gave place to the advent of the fore-and-aft compound and triple-expansion types. Of the fore-and-aft compound type we have five engines built earlier than 1870. This type also reached the height of its popularity during the years 1880 to 1890, and then gave way rapidly to the triple-expansion engine, which makes its first appearance during this term with 67 examples, and which has held its supremacy with 147 engines built since 1890. The first quadruple-expansion engine was built in 1889, and since that date there have been 6 vessels equipped with this type of engine, and there are several of this type now under construction. Of the paddle-wheel boats, you will note that 33 engines are of the common and well-known walking-beam type, while 19 are either horizontal or inclined engines.

It is also interesting to note the changes which have taken place in the types of boilers. The marine fire-box boiler is the most common type, though it has lost its prestige, the Scotch boiler having rapidly displaced it of late years. Seven hundred and thirty-one boilers of this type are in use to-day, 18 of them having been built earlier than 1870, 97 of them between 1870 and 1880, 392 between 1880 and 1890 and only 224 since 1890. The Scotch type of boiler has one example built earlier than 1870, 8 between that and 1880, 193 between 1880 and 1890, and 348 built since 1890, a very rapid increase during the last seven years. The marine water-tube boiler is of more recent date, only one having been built earlier than 1880. There are none of this type now on the lakes built between 1880 and 1890, but there are 35 vessels, built since 1890, equipped with this type of boiler, and there are several vessels now under construction which are to be equipped with this type of boiler, and it is the opinion of many engineers that the water-tube boiler is the

coming boiler for marine use. It is also interesting to note the gradual increase in pressures in boilers built during these several periods. Of those built earlier than 1870, 100 pounds per square inch is the highest pressure, and there is only one boiler of this period carrying as high as 100 pounds, and only one carrying 90 pounds, most of the boilers built during this period carrying pressures from 40 to 55 pounds. Most of the boilers built between 1870 and 1880 carry either 80 pounds, 90 pounds or 100 pounds pressure, though there are a few built during this period carrying considerably higher pressure, and one carrying as high as 200 pounds. During the period of 1880 to 1890, 276 boilers carry 100 pounds pressure or less, and 318 carry more than 100 pounds; but there is only boiler built during this period carrying as high as 200 pounds, 29 carrying 160 pounds, 39 carrying 150 pounds, and the balance ranging from that down to 100 pounds pressure. Since 1890 the tendency has been to a considerable increase of pressure; only 91 of the boilers built during this period carry as low as 100 pounds, while 517 carry pressures higher than 100 pounds. Of this number 75 carry 120 pounds; 82, 125 pounds; 45, 150 pounds; 83, 160 pounds, and from that on up to 300 pounds, there being one boiler carrying this highest pressure, 2 boilers carrying 265 pounds pressure, and 12 boilers carrying 250 pounds pressure.

In our survey of boilers it was not deemed necessary to make hydrostatic tests, as every boiler has to pass a Government inspection and test each year before the vessel is licensed to sail, and our survey has, therefore, been only for condition and to ascertain the care that they were receiving. In this connection we have found 295 boilers to be patched inside and 264 to have patches on the outside; 82 boilers are shown to be poorly fastened to the hulls of the vessels; 139 boilers are without stop valves between them and the throttle valves; there are 191 cases where the slip joints in the main steam pipes are not protected with safety guard bolts; there are 134 cases where there are no cocks between the feed-check valves and the boilers; and there are 165 cases where the feed-check valves are only common pipe checks.

Referring back to the subject of engines, it was rather surprising to find the lack of uniformity of proportion of parts of these machines. There seems to have been no hard and fast rules for the construction of engines on the lakes, and each builder has followed his own ideas, to a greater or less degree, in the proportion of the several parts of the engine he built, as well as in its special design. In the item of crank shafts we have found that about 400 were of the solid-forged type, 17 of these being of steel and 383 of wrought iron; 780 were built-up shafts, of which 23 were of interchangeable sections, 13 of them being of steel and the balance of wrought iron. Of the total number, 354 were found to be light in section, according to Lloyd's rule for determining the size of crank shafts. We also found 106 cases where the intermediate shafts were light of section, and 387 cases where the propeller shafts were light of section, by these same rules; and we found 48 cases where the shaft couplings were reinforced, either on account of breakages or because of developed weakness. There were also found 296 cases where the thrust bearings were insufficient to properly relieve the crank shafts from fore-and-aft strains. A perhaps more serious defect, from the insurer's standpoint, was found in the light crosshead connections, we having found 446 cases where crosshead keys were too light and 54 cases where the nuts fastening piston rods into crossheads were small. This is a serious defect, and several recent accidents have occurred from light construction in these parts.

A point which seems to have been very sparingly covered by authorities on engine design, and yet which seems one of vital importance to us, is the bolting of cylinders to columns, of columns to bed plates, and of bed plates to seatings in marine engines. The strain to which each of these parts is subjected being a direct strain, the necessary strength of these parts is easily found by computation based on the steam pressure and the size of the cylinders. In these parts we have found 340 cases where the cylinders were too lightly fastened to the columns, 68 cases where the columns were insufficiently secured to bed plates, and 64 cases where the bed plates were not sufficiently bolted to

their seatings. We have also found several cases where the fastening at the ends of connecting rods is too light for safety.

While it is true that in most cases where light crosshead connections and insufficient bolting of cylinders to columns, columns to bed plate and bed plate to seatings were found, the condition has occurred through the replacing of old, worn-out boilers by new boilers of higher pressure, without increasing the parts of the engines, it is also true that we have found several cases of recent construction where these parts were originally made entirely too light for safety. The use of relief valves on steam cylinders has been appreciated only since the compound engines and higher steam pressures have become common, but it is a point which has become one of vital consideration. We have found over 650 cases where the cylinders were not so safe guarded. Many of these, however, were non-condensing engines, carrying only moderate steam pressures, but we have found 58 cases where cylinders were cracked and patched, and in most of which the damage might have been avoided had there been proper reliefs.

In the cast iron parts of engines, such as bed plates, columns and channel plates, the builders on the lakes have not been sparing in the use of metal, though we have found 66 cracked bed plates, 63 broken columns and 5 cracked channel plates. Still, in almost all of these cases, the breakages have occurred from carelessness on the part of the engineers in allowing water to become entrapped and allowed to freeze in winter.—"Marine Review."

TRIPLE VERSUS TWIN SCREWS.

Writing upon the result of a series of tests carried out by the French Government at Brest, with the battle ship *Charlemagne*, and intended to determine the relative merits of twin and triple screws, a correspondent says: "The aim in adopting three screws is to get low speeds by working one or two of the engines at maximum, or a high and therefore efficient power, leaving the other idle. Trials were made with the *Charlemagne* developing the same power with two and with three engines. With the two side engines working, the power realized with 105 rev-

olutions was 5,258 indicated horse power, while with the three engines running the revolutions were reduced to 94 per minute for 5,166 indicated horse power. With the three engines doing 94 revolutions, the coal consumption was equal to 1.47 pounds per horse power per hour, and at 105 revolutions, with two enignes, it was only 1.33 pounds per horse power per hour, so that the two screws for this particular power gave a higher economy to the extent of 9 per cent. when the consumption per 1,000 miles is taken into consideration. The coal consumptions given, it is well to note here in passing, do not include that for any of the auxiliary machinery, pumps, electric engines, steering, etc. If the two screws working thus at half power were more economical than the three, wherein is the advantage of the three screws? Moreover, there was a better speed for the twin engines running than for the triple screws. The difference in the total power in each case is inappreciable, yet, with the three engines, the speed was only 13.95 knots, against 14.16 knots for the two engines.

It is evident that the slip of the three propellers is greater than with the two, and that is probably accounted for by the fact that the center propeller has to work in more or less disturbed water. Trials were not made in this case with one screw propeller only, but with other ships the utility of the three engines has not been established. A Russian ship, with the center screw running and the two side screws idle, required the same power to get 10 knots that gave 12½ knots speed to a ship of the same size and displacement with only two screws, so that while the consumption of the one engine might be less per unit of power, this advantage was forfeited because of the greater power required. The *Charlemagne* on her 9,000 indicated horse-power trial of twenty-four hours duration, made 16.41 knots for 9,270 indicated horse power, with the three engines running 112½ revolutions, and the coal consumption was 1.547 pounds per indicated horse power per hour. This does not include auxiliary machinery, so that it is quite 30 per cent. higher than is realized in our later British ships. Again, as to speed, our ships of the same size and type get 17 knots for the same power.

LESSONS FROM THE DESTROYED SPANISH SHIPS.

The report upon the condition of Admiral Cervera's vessels after the battle of July 3d, has been too widely published to make it advisable to reprint it herein. It has been read with great interest and profit by naval people everywhere:

The general conclusions of the Board were, briefly, as follows:

The ships *Infanta Maria Teresa*, *Almirante Oquendo* and *Vizcaya* were destroyed by conflagration, caused by explosions of shells in the interior and setting fire to the woodwork. The upper decks, and all other woodwork, are entirely consumed except at the extremities.

Many of the guns on board the burned ships were found loaded at the time of the Board's visit, indicating the haste with which the crews were driven from their guns.

The conclusions drawn by the Board from its examination of the captured Spanish ships are:

That the use of wood in the construction and equipment of warships should be reduced to the utmost minimum possible.

That loaded torpedoes above the water line are a serious menace to the vessel carrying them, and that they should not be so carried by vessels other than torpedo boats.

That the value of rapid-fire batteries cannot be too highly estimated.

That all water and steam piping should be led beneath the protective deck or below the water line and fitted with risers at such points as may be considered necessary.

ELECTRICAL TRANSMISSION OF POWER IN ENGINEERING SHOPS.

One of the American electrical journals has recently published some figures relating to the cost of maintenance of the electrical power-distributing system in the Baldwin Locomotive Works, U. S. A. In this works there are 215 motors in use, varying in size from 2 to 50-horse power, and having an aggregate capacity of 1,930 horse power. The total cost of maintenance (labor and *matériel*) is found to be $2,500 per annum, or about 4 per cent. on the capital outlay of the plant. This sum of $2,500 is stated

to be about the same as that of the older system. The advantages claimed for electrical transmission are: 1. Greater headroom in the shops, and consequent greater facility for using traveling cranes to aid in shifting work. 2. Decrease in transmission losses. One shop that formerly absorbed 150 horse power is now worked with 80 electric horse power at the switchboard, a saving of 47 per cent. of the power formerly used. A still more striking illustration of loss of power by the older system is that of a planing mill on a western railroad which when in full work required 500 horse power. It was found that when no work was passing through the machines, 375 horse power was still necessary to drive them at the normal speed, and that therefore 75 per cent. of the power generated in this mill was used for overcoming frictional resistances of the shafting and machinery. One of the latest important conversions from the older system to the new in this country is that of Messrs. Willans & Robinson's Engine Works at Rugby. In the Thames Ditton Works, shafting was chiefly used, but in the new Rugby Works shafting is conspicuous by its absence, and electric motors have been installed throughout the shops. This is a change that will undoubtedly extend to other engineering works as the advantages of electrical transmission become better known.

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

The Sixth Annual meeting of this Society was held in New York City, No. 12 West Thirty-first Street, on November 10th, but owing to the fact of having the main portion of this number of the JOURNAL already made up, we are unable to reprint *in extenso* in this issue any of the many valuable papers read. The following abstract of the proceedings, however, will be found full of interest and are drawn from the report published in "Engineering News" of November 17.

President Clement A. Griscom called the meeting to order, and Secretary Francis T. Bowles read his report. The list of candidates presented by the council was passed upon by acclamation, after which the officers for the past year were re-elected,

Mr. G. W. Dickie, of the Union Iron Works, being substituted for the late John F. Parkhurst, as member of the council. Following this, Mr. Griscom, the president, read a brief address.

The reading of papers began with one by Mr. Arthur B. Cassidy, entitled, "The Standard Navy Boats." This paper briefly reviewed the various types of small boats, such as dories, whale boats, surf boats and the like, and then described the several types of steam launches and boats now adopted by the United States Navy Department as standard for use on all naval vessels.

This paper was discussed at considerable length by several members, the discussion being concluded by Secretary Bowles, who stated that the present boats were the outcome of an enormous amount of experience, and were a compromise between the builder and user, whose ideas were naturally somewhat antagonistic.

The second paper, by Assistant Naval Constructor Lawrence Spear, U. S. N., entitled "Bilge Keels and Rolling Experiments, U. S. S. *Oregon*," was then read by Prof. W. F. Durand.

He stated that the original designs for the battle ships *Oregon*, *Indiana* and *Massachusetts* called for bilge keels about 30 inches deep; but to facilitate docking, these keels were omitted in building. This omission was at the time in line with the best foreign practice, and theoretical considerations led to an underestimation of the steadying effect of bilge keels of any practical dimensions as applied to slow-moving ships of large displacement and inertia.

But while these ships were nearing completion foreign practice, and especially that of England, underwent a change, as the result of comparisons of sister battle ships with and without keels. Experience with the *Oregon* class at sea showed that some steadying influence was necessary; though the maximum inclination of the *Oregon* herself never exceeded about 22 degrees, under a long, low swell. Bilge keels were put on the *Oregon* in January, 1898. These keels had a maximum depth of 34 inches near the ends, tapering to 14 inches amidships. The comparison in rolling effect, with and without keels, is shown in the following table:

	Keels.	
	Without.	With.
Date of trial	Dec. 30, 1897.	Feb. 17, 1898.
Draft, forward, feet and inches	22–9½	22–9
Draft, aft, feet and inches	23–8½	23–8
Draft, mean, feet and inches	23–3	23–2½
Displacement, tons	9,810	9,790
Metacentric height, feet	3	3
Mean period, single swing, seconds	7.6	7.83
Weight of coal, tons	115	50
Weight of ammunition, tons	26.7	26.7
Bilge keels, number	0	2
Length, feet and inches	207–6	
Greatest depth, inches	34	
Least depth, inches	14	
Total area, square feet	830	
Effective radius, feet	34.4	

Except as above stated, conditions were alike in both cases. At slack water, and practically no current, with ship moored and without keels, 350 men running across the deck caused an inclination of about 7 degrees from the vertical; with 200 men acting in conjunction with the 8-inch turrets, an inclination of nearly 6 degrees was reached. Without bilge keels the rolling was practically isochronous within the range of experiments. With bilge keels, the period for single swing decreased slightly with the amplitude of roll. As measured by the radius of gyration, the period without keels was 7.6, and that with keels, 7.83, a difference of a little over 3 per cent.

The results of the observations were plotted as "curves of declining angles" and "curves of extinction," and these were compared with corresponding curves for the first-class English battle ship *Revenge*, in light condition. It is noted that the *Oregon*, starting at an inclination of 6 degrees, required, without keels, 60 swings to reduce this inclination to 2 degrees, while with keels the corresponding extinction required only 10 swings. For the *Revenge* the corresponding figures were 45 and 8. Taking the extinction value of the *Oregon*, without bilge keels, as unity, the curves gave the following results at an inclination of 5 degrees from the vertical.

Oregon, light, no keels	1.0
Revenge, light, no keels	1.32
Oregon, light, with keels	7.36
Revenge, light, with keels	8.18

The *Oregon's* loss of range per swing with this inclination is thus over seven times greater with keels than without; and this figure holds approximately true for any other angle within the range of experiments. In the case of the *Oregon*, the same forces that would produce an unresisted roll of 20 degrees would only produce one of 6 degrees with the keels in place. In the case of the *Revenge* these figures were about 18 degrees and 6 degrees; or, broadly speaking, the roll, with keels, under identical conditions, would only be one-third as great as without them.

The paper concluded with the statement that while service conditions prevented fuller trials of the *Oregon*, the English experiments proved, what was to be expected, that the bilge keels had an increased effect when the ship was under way, and that the steering qualities were improved and tactical dimensions were decreased by the addition of keels.

The discussion was opened by Mr. J. G. Tawresey, who said that arguments advanced for abandoning the bilge keel did not meet the approval of practical men. That the reduction of rolling was due to wave making by the bilge keels there could be little doubt, and it is well known that the best method of creating model waves was by oscillating a plane. He considered that the bilge keels did not disturb to any extent the natural wave lines of the vessel.

Prof. W. F. Durand read a discussion of the paper, calling attention to the difference in results obtained by the use of present formulæ and the actual values obtained by the test described. The bilge keel was not a plane, and the formulæ at present in use were very unsatisfactory.

Secretary Bowles stated that a few years ago bilge keels were placed on all of the large vessels of the navy. Recently, for various reasons, several battle ships had been built and launched without these keels, with the result that these vessels were not really safe, and it was necessary that keels be put upon them. He ven-

tured to say that in the future no battle ships would be built without bilge keels.

Assistant Naval Constructor R. M. Watt mentioned that the *Massachusetts* was keeled in sixteen and one-half working days at the Brooklyn Navy Yard, under Mr. Bowles.

The next paper, "Portable Pneumatic Riveters in Shipbuilding," was then read by its author, Mr. W. I. Babcock, President of the Chicago Shipbuilding Co.

Mr. T. F. Newman said he had used pneumatic percussion riveters in connection with the construction of vessels for the revenue marine service, and the government inspectors passed such work readily. Where it was necessary to mill rivets, as in the case of shell riveting, he had found the saving only about 25 per cent.

Mr. John Platt called attention to the methods of hydraulic riveting used in England, and remarked that he was surprised to find people still using blows instead of steady pressure here. He thought that large rivets could not be driven by percussion riveters. The Holland & Wolff Works use an immense crane which spans the vessel. Pendant from the crane are six 40 to 50-ton riveters, which are used to rivet framing, etc. In England and Ireland hydraulic riveters are extensively employed. To prevent freezing crude glycerine was used in proportions of one-third glycerine to two-thirds water. He had no doubt, however, but that for small work percussion riveting was satisfactory.

Mr. Tawresey believed percussion riveters could do all sorts of riveting in a rapid and satisfactory manner. The noise, was, of course, disagreeable and had a bad effect on all concerned, possibly increasing costs slightly.

Mr. L. R. Pomeroy asked what were the limitations of percussion riveting. He knew several locomotive builders had tried pneumatic riveters and had later given them up because they could not get steam-tight joints with them.

Mr. Babcock, in answering the various statements and questions, said that he had closed 1-inch rivets, but he knew of several cases where rivets up to 1¼ inches had been set with the same style of hammer that he used. This need not be the limit, how-

ever, as it was simply a question of sizes of hammers. The air-pressure at the end of the hose should not be less than 100 pounds, and they were now putting in machinery which would give 125 pounds. He preferred pneumatic to hydraulic riveting, because of its simplicity and general applicability. The Harlan & Wolff traveling crane is very heavy, and only of use for certain kinds of work. He admitted that the noise of percussion riveters was objectionable, but said that there was practically no limit to their use, it being almost as easy to operate a 10-foot gap as a 4-foot one.

In one vessel recently riveted up by hand 51,306 shell rivets were used, each costing 3.99 cents. In another instance 74,493 shell rivets were placed by the percussion riveter, mounted upon the frame described in the paper, and cost 2.96 cents per rivet. In response to a question, he stated that as far as he could see there was no reason why long rivets could not be driven in this way.

Afternoon Session.

Immediately after calling the meeting to order, the President introduced Capt. Wm. H. Jaques, who presented a series of stereopticon views of foreign submarine boats, and the American boat *Holland*.

The regular programme was resumed by Secretary Bowles reading a paper by G. W. Dickie, entitled, "Torpedo Boat Destroyers for Sea Service, with Special Reference to the Conditions that Prevail on the Pacific." In this the author said:

A torpedo-boat destroyer must possess other qualities than those necessary for the destruction of torpedo boats. The destroyer must be a sea-going vessel, able to remain at sea with the fleet to which she is attached or to make independent voyages.

The work of the torpedo-boat destroyer is to prevent the torpedo-boat attack, and is, therefore, performed in open water. She must keep the sea with the attacking fleet, watching every place of refuge for a torpedo boat. She must, therefore, possess speed equal to that of the torpedo boat; a battery powerful enough to destroy her; sea-going qualities to enable her to

keep a watch in spite of weather. She should be able to cover long distances at a high rate of speed and in stormy weather. The fleet to which she is attached should not be delayed and hampered by guarding her from harm; she ought, instead, to be able, in all kinds of weather, to act as a scout in advance of the fleet, keeping the larger vessels informed as to the whereabouts of a possible enemy. Such would be an ideal torpedo-boat destroyer.

It cannot be said that the present type of torpedo-boat destroyer comes near meeting these requirements. Quite a large number of destroyers now meet the requirements in the matter of speed, if required for a short time only, in smooth water, and if in good order; but the one quality of speed has been made paramount to all other qualities to such an extent that the full speed can only be reached when the conditions are such that the sea-going qualities can be neglected.

The great distance between harbors on the Pacific Coast and the almost universal condition of rough water along the coast from Point Conception in the south to Cape Flattery on the north, with only one place of refuge, renders it necessary that any vessel for practical service outside the harbor of San Francisco or the smooth waters of Puget Sound must have good sea-going qualities and be able to remain outside in all conditions of weather.

The qualities necessary for this service are not possessed in any degree by the present type of torpedo-boat destroyer. While they have made voyages of considerable length at sea, they have done so usually under the care of a larger vessel.

The 420-ton destroyers lately ordered by our Government are a decided improvement in this class of vessel, but we do not think they are fitted even yet to meet the special conditions of service on the Pacific.

The annexation of the Hawaiian Islands requires a much greater radius of action for such a vessel, and, we think, a different treatment. In fact, we maintain that if 30 knots or over is aimed at as the supreme speed, a sufficiently staunch sea-going vessel cannot be produced in the present state of the art,

and that the present so-called 30-knot torpedo-boat destroyers have not, in fact, the speed with which they are credited as being available when required.

If these boats and their machinery were made more substantial, so that their full power could be exerted at any time and without risk, and the hull stand a moderate sea without danger, the 30-knot boat, by reason of the extra displacement, would drop to about 27 knots; yet we venture to assert that such a boat, ordered to reach a point at sea, say 100 miles distant, in the shortest possible time, would reach the objective point in less time than the regulation 30-knot boat that is said to get a horse power in 50 pounds weight of machinery. A large proportion of naval vessels rated at high speeds, especially those over 20 knots, have obtained such speeds under conditions that cannot be reproduced when the speed is most needed, and a good, reliable, heavy-engined, 16 or 17-knot boat may outstrip them in a fight.

Mr. Dickie then outlined plans for a destroyer of 640 tons displacement and 7,000 I.H.P. with a maximum speed of 25 knots and a sustained sea speed of 15 to 20 knots. He provided an armament of six 6-pounders, two 4-inch rapid-fire guns and two submerged torpedo tubes aft of the engine room. He believed such a boat would show better speed under regular service conditions than any of the so-called 30-knot torpedo-boat destroyers, and for sea-worthiness, habitability, or fighting capacity would far outrank them.

The discussion of this paper was opened by Mr. Platt, who took exception to the use of the term "torpedo-boat destroyer." The craft described should properly be called a "torpedo cruiser." The boat outlined by the author possessed many desirable features, but he saw no reason for limiting the speed to such a low figure. He had been present at the test of an English destroyer of 300 tons, which had made 27 knots in a rough sea and against the wind, or 32 with the wind. Such a boat would easily make 30 knots in moderate weather. Further, in English practice, it was customary to limit other mat-

ters, such as coal consumption, the maximum at present allowed being 2½ pounds per horse power.

In answer to a question by Mr. Stevenson Taylor, Mr. Platt stated that speed ratings were obtained, in the case of such boats, by averaging six runs over a measured mile between points. During these runs the turns of the screw were accurately determined, and thus data obtained from which the speed can be obtained at any time by knowing the turns of the screw.

In connection with this discussion the first topical question "The Utility of Torpedo Boats, and Has the Submarine Boat a Place," was introduced, and Mr. Bowles read a letter from an officer who had commanded torpedo boats during the recent war. The opinion seemed to be that the torpedo boat was of great utility, but that a lack of drill and an insufficient complement of officers and men, accustomed to the handling of such boats, had made them of considerably less service than they might otherwise have been. The systematizing and standardizing of boats and equipment and the careful selection and drilling of the crews was strongly advocated.

Lieutenant A. P. Niblack, in a letter, compared our torpedo-boat system with the careful and complete methods of foreign countries, and regretted that the custom of hauling the boats out of the water was being adopted here.

A letter from Lieutenant-Commander Kimball, who commanded the torpedo-boat division of the North Atlantic Station during the recent war, advocated the submarine boat. He stated that if it be admitted that the torpedo is of use, then the submarine boat, which is no more than a torpedo with a human mind directing its movements in place of the usual automatic devices, would be of far more service. If trenches and mines are useful or necessary on land, it was quite as essential to take advantage of the protection afforded by the water. The submarine boat is the only kind of inexpensive boat that can move up close to an enemy. Such a boat with a crew of five men could attack land batteries and enter harbors. It could make blockades ineffective, destroying mines, etc.

Captain John Lowe spoke in favor of the submarine boat, and

pointed out how much time, money and anxiety would have been saved had the United States had such a boat at Santiago. He believed that the future would see submarine dispatch boats, gunboats and observation boats.

Assistant Naval Constructor R. M. Watt, who had had charge of the repairs of the torpedo boats sent to the New York Navy Yard, considered the *Morris* the ideal type of torpedo boat, operating from a base. He favored only one type of torpedo boat, about 100 tons, and would then at once jump to vessels of 400 to 500 tons, building a vessel about as outlined in Mr. Dickie's paper for service as a scout or dispatch boat. Mr. C. D. Mosher did not think the time had come for standardizing torpedo boats. The speed and power for a given displacement were yearly increasing, and we must have as high speeds as our enemy. Handling had a great deal to do with the poor showing of our boats. At present experiments were being conducted in England by Mr. Parsons, which, if successful, might revolutionize torpedo-boat construction.

Mr. J. G. Tawresey spoke as an unbeliever in torpedo boats. He admitted their moral effect, but based his views largely upon the fact that at present there were no indications that torpedo attacks would be successful. He would not be afraid of torpedo boats in the open sea. He was of the opinion that torpedo boats were entirely too light for any sort of sea service. Under special conditions they might be dangerous antagonists, but conditions must be taken just as they exist when the chance to fight occurs. So far, they had been used simply as dispatch boats and not with the best of success. They should not in any case be used for any other than the designed purpose.

Mr. F. L. Du Bosque favored the standardization of torpedo boats, so that a man when ordered from one to another, could at once perform his special duties properly. Water-tube boilers on some torpedo boats had proven a success, and there was no inherent reason why all should not prove successful if properly handled. The great trouble was that the boilers on a torpedo boat were used spasmodically.

Mr. John C. Kafer considered the construction of torpedo

boats faulty. They never did what was expected of them, and the speeds credited to them were not reached in actual service. He did not favor any boat that could only keep up its speed from three to five minutes.

Mr. R. M. Watt called attention to the fact that in a torpedo-boat attack it was contemplated to have, say, half a dozen boats start from different directions. In the Battle of Manila two improvised torpedo boats started from 4,000 yards and one of them succeeded in getting within 1,200 feet.

Mr. Stephenson Taylor considered the trouble due largely to the make up of the crews, most of them being men not familiar with the tools they were using. The *Scorpion*, for instance, gave no trouble until taken by the Government.

Mr. Bowles explained that the service of a yacht under ordinary conditions and the conditions imposed upon the converted yachts employed in Cuban waters was entirely different. Most of the vessels on the blockade were forced to use salt water at times in the boilers.

Mr. F. Meriam Wheeler then read a paper, entitled "Economy Test of a Unique Form of Feed Pump."

In discussing this paper Lieut. Walter M. McFarland, Engineer Corps, said that it must be remembered that the service of engines in the merchant marine and in naval vessels was entirely different. In the former they were started up and ran continuously for six or seven days, while in the latter they might be started or stopped every five minutes. Hence it was that the converted vessels gave so much trouble. It was, therefore, necessary to have the various pumps separate from the main engines and leave the engines free to propel the vessel alone. Whatever form of pump was adopted must be designed with an idea of saving weight and economizing coal.

NOVEMBER 11.—MORNING.

This session began with the reading of a paper, entitled "The Steam Yacht as a Naval Auxiliary," by Mr. W. P. Stephens.

The work of reconstruction which has been under way in the

United States Navy for the past fifteen years has been limited almost entirely to the strictly fighting arm of the service—the battle ships, cruisers and torpedo craft. Indispensable as they are, these of themselves do not constitute a perfect navy; in fact they are of comparatively little use without a large attendant fleet of auxiliary craft—transports, colliers, water boats, repair ships, supply ships, hospital ships, and small craft for various uses.

The condition of the Navy at the outbreak of hostilities between the United States and Spain may be briefly summed up as strong in its personnel; comparatively strong in fighting vessels, guns and armor; and absolutely unprovided with auxiliaries of all kinds. Of all the urgent work demanded, both ashore and afloat, nothing was more immediate and pressing than the creation of an efficient fleet of auxiliaries.

The possibilities of the yacht fleet at the present time for conversion to war uses were, even from a theoretic standpoint, far from promising. Many of the vessels were ill-fitted in model for real service at sea; there was a lack of displacement for the added weights of armament and ammunition, of berthing space for crew, of bunker space, and suitable locations for magazines. The nominal speed, in many cases low in itself, was not realized even in smooth water, and in a sea there was a serious loss of the average working speed. There was no protection, no distilling apparatus; the capacity of the water tanks was generally inadequate, and the decks were not designed to withstand the shock of guns. The draught, as a rule, was greater than was necessary or desirable. The nature and extent of these defects were fully realized at the outset, but under the circumstances there was no other course but to take the yachts as they were and to make the best of them. All things considered, they have done their work quite as well as was to be expected; they have served a certain necessary purpose, and they were capable of doing even more had it been required of them.

The work of the yachts, their success and failures taken together with the work of other small craft, such as tugs, lighthouse tenders, etc., impressed into the same service, seems to

indicate the desirability of the creation of a new type of small auxiliary not at present recognized on the Navy list. The speed may be placed at not over 18 knots. This, however, is not to be measured by the conventional yacht standard, by which an 18-knot steam yacht takes the wash of a good 12-knot tug, but means a reasonable approach to the designed speed under ordinary service conditions at sea, and the ability to keep with the fleet even in bad weather. The model should possess sea-going qualities of the highest class; the draught should be limited to 11 or even 10 feet, as a maximum; the construction should be durable, with ample scantling both to carry the armament and to insure a long life with ordinary care in laying up; the engines should be strong and reliable, the bunker space as large as possible, and, as deck and side protection will probably be impracticable, especial attention should be given to the water-line protection of machinery and magazines through their location and the disposition of the bunkers.

The intended uses of this class call for three sizes: for sea work, as dispatch boats and tenders, and for picket duty, vessels of not over 800 tons displacement. The next size to be of about 400 tons displacement. The third size, for harbor patrol service, to be of about 200 tons. A speed of 15 knots would suffice for this service, but they should be capable of towing a vessel out of possible danger.

In the discussion, Capt. Jacob W. Miller said: Although we were fighting a nation in the late war which did not make a second line of defense necessary, the yachts did not meet the conditions required. The yachts were purchased at maximum prices, and we could have got boats better fitted for the work if the same money had been expended some years ago. Yet the pick of the yachts in the United States were taken. None of the yachts could do over 10 knots continuously for twenty-four hours. There was not sufficient berthing space for the crew on converted yachts, and they were not rough and ready enough. Boats for harbor work must be strong enough to permit running up alongside of sailing vessels that are drifting in mine fields. Converted yachts were serviceable in very few particulars. He

did not favor three types of such vessels, and considered two quite sufficient, one for inner patrol work, and one for outer.

Mr. J. G. Tawresey, who was a member of the Auxiliary Cruiser Board, said: The orders given to the board was to select vessels that would act as "eyes to the fleet." We had to take such vessels as were available. As fighters they were makeshifts, filled with objectionable features. For one thing, they were tinder boxes. I want to emphasize the fact that we cannot improvise a navy from yachts and tugs. There was a very useful field for such a boat as suggested by the author, and the design presented would, he thought, quite fill the want.

Mr. John Platt called attention to the fact that no fast gun boats had been built in this country. A speed of only 18 knots for a vessel of 850 tons was very low, as it was quite possible to get 22 knots. The British Government had built a large number of torpedo gun boats with speeds ranging from 18 to 22 knots.

Mr. Bowles felt that there was a decided need of such a boat as was described in the paper, but a speed of 16 knots, provided it could be kept up, was sufficient. Referring to the lack of crew space on the converted yachts, Mr. Bowles said that as all the naval militia wanted to see service, the boats were often overcrewed. He favored only one size of boat, because experience had shown that the wrong size was always around when an emergency arose.

Lieut. W. P. White considered the inshore patrol or mine-field protection to be a function of such sea-going tugs as the Government could impress, and it was out of the question to maintain a fleet of small boats for this purpose. The armoring of scout boats to any extent was inadvisable. In time of peace the various vessels should carry more than their war complement, so that in emergencies the extra men could at once man auxiliary or new vessels. The manning of vessels with entire naval militia crews was, he thought, poor policy, and it was far better to send them out as part of the regular crew of vessels in service. Battle ships were of the first importance, and hence money should first be put into their construction, leaving dispatch boats, etc., until later.

Mr. W. P. Stephens, in closing the discussion, said he did not mean to insist upon three classes. There might only be two classes, the larger being represented by the boat designed by Mr. Dickie. Lower speeds should be used and engines and other apparatus employed which could be successfully operated by inexperienced men.

In the absence of Chief Constructor Philip Hichborn, the secretary read the opening paragraph of his paper on "Designs of the New Vessels for the U. S. Navy."

The secretary suggested that the question of the utility of monitors be discussed in connection with the discussion on this paper.

Capt. William C. Wise said: It is my belief that the *Puritan* is the finest fighting ship in the United States Navy to-day. She could battle with a whole fleet. With twenty *Puritans* we could defend the whole coast.

Prof. Cecil H. Peabody discussed briefly the disposition of armor on monitors and battle ships. He did not favor standardization of battle ships and torpedo boats beyond those built at any one time, since standards at times interfered with progress.

Col. E. A. Stevens asked if the conditions during the battle of Santiago were normal enough to permit the records of hits given the Spanish vessels being used for future design. If so, it would seem that such heavy armor was unnecessary, for the large shells did not seem to hit.

Afternoon Session.

At the afternoon session the first paper presented was "Methods of Securing Water-tight Work," by Assistant Naval Constructor H. G. Smith, U. S. N. The paper referred especially to ship construction, but some portions of it are of general interest to all designers of riveted work.

To facilitate discussion, since the general subjects were the same, the next paper, "Tests of the Strength of a Longitudinal Bulkhead Separating Two Engine Rooms," was then read by its author, Naval Constructor J. J. Woodward, U. S. N.

In discussing the papers, Naval Constructor J. G. Tawresey

said that there should only be one kind of bulkhead—a strong and absolutely water-tight one. Historically, there might have been two classes, the tight and the leaky, but in the future only the tight should be accepted. It must not be understood that the navy alone found leaks, for they were just as troublesome in the merchant marine. He considered that a good deal of the blame for leaky bulkheads could be laid to the draftsmen.

Professor Peabody considered the experiments described in the papers just read, as very important. He thought the Navy Department should conduct a series of experiments and put the data obtained in form so that it could be used for future design.

Mr. T. F. Newman saw no reason why bulkheads and ship's bottoms could not be made absolutely tight. On the Great Lakes they managed to secure such tight work that in many instances where the outer plating of the double bottom of vessels carrying grain had been injured, not more than 30 or 40 bushels of grain would be damaged, owing to the tight inner bottom.

Mr. John C. Kafer thought that bulkheads were made to keep out the bulk of the water, and, except in tank steamers, there was no need of builders going to great trouble to stop every little leak, provided the bulkheads were strong enough to stand the strain.

Col. E. A. Stevens asked what conditions were imposed in the United States service. In the British service he understood that the stiffeners must be strong enough to stand all strains without depending upon the sheeting.

In reply Mr. R. M. Watt read a letter showing how the stiffeners and bulkheads were calculated for the *Texas*, and a comparison of the bulkheads of a number of United States vessels.

Mr. Bowles objected to placing 50 per cent. of the blame for leaky bulkheads upon the draftsman. The trouble was that after a bulkhead was made tight it was drilled full of holes by the machinists and electricians.

Mr. J. J. Woodward objected to any plan of bulkhead bracing that would weaken the protective deck, and said that where there was a conflict between the fighting strength of a vessel and a small amount of leakage, the latter should be disregarded. In response to a question, Mr. Smith said that in the test of the double bottom

of the *Brooklyn* the time and labor of five men was required constantly for fourteen months.

Owing to the short time remaining, the paper of Mr. Walter A. Post, on "An Electrically Operated 150-Ton Revolving Derrick," was read by title only.

The last paper of the meeting, "Stability of a Battle Ship Under Damaged Conditions," was read by its author, Prof. C. H. Peabody. This was a report of a series of tests made with a small wooden model representing a battle ship with its superstructure removed. The model, with inclining apparatus in place, was ballasted so that it floated at the proper water line, and so that it had the proper metacentric height. Then blocks, representing the parts or compartments laid open to the sea, were cut out and lead weights were fastened in place to compensate for the wood removed. Then various measurements were made to determine the initial stability and the stability at various angles of heel. The facts developed were illustrated by a series of diagrams and a number of curves. Discussing the paper, Mr. Woodward suggested that in an actual battle ship the superstructure could be made to assist in keeping the vessel afloat. Professor Peabody considered that the many openings in the superstructure would prevent its adding to the buoyancy of the vessel, should it start to capsize.

The discussion of the following topics was then taken up:

First. Under the circumstances of the blockade at Santiago, which was the more economical method of maintaining the boilers in readiness for immediate action—banking the fires or keeping them spread but very thin?

Second. Can you give any data as to the cost in coal of maintaining the engines and boilers in readiness for immediate service?

Mr. John C. Kafer read a letter from Chief Engineer Milligan, of the *Oregon*, which stated that the fires on the *Oregon* were spread thin, there being from 24 to 27 tons of coal burned per day. The *Iowa* used banked fires. Mr. Kafer considered banked fires more economical, but not so advantageous for quick steam making as keeping them spread.

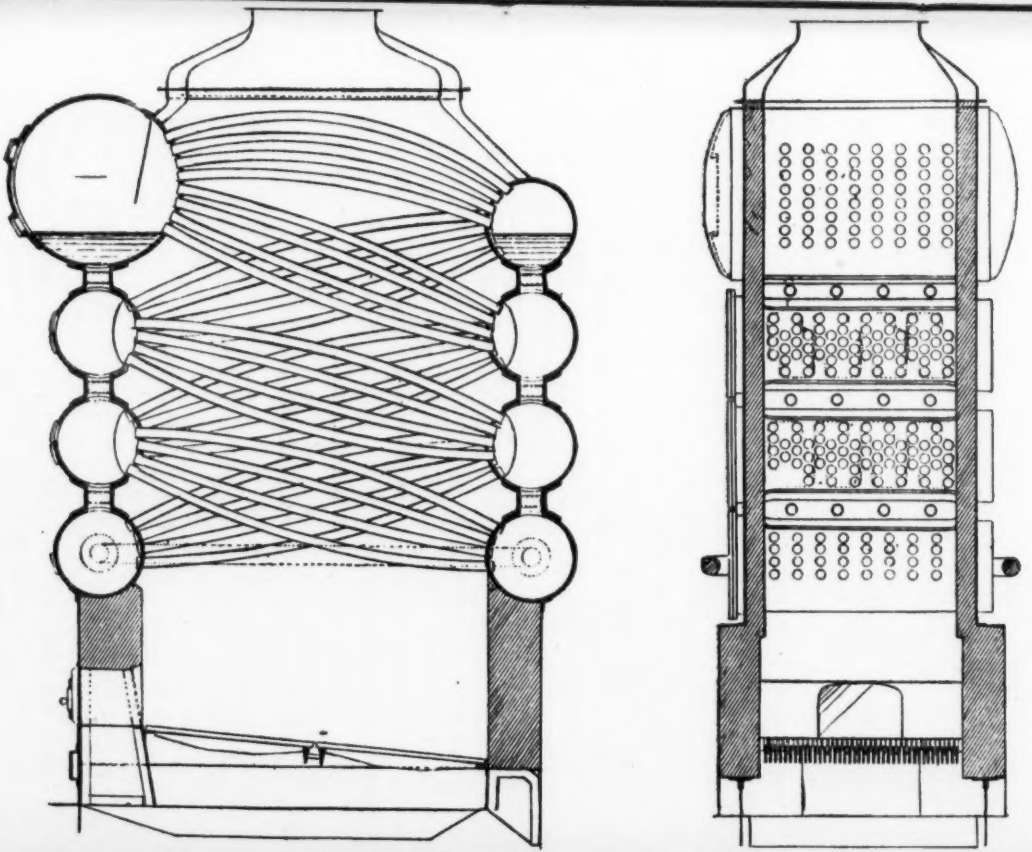
Lieut. Walter M. McFarland presented some figures showing

the coal consumption on the *Indiana*, *Massachusetts*, *Oregon* and *Iowa*, showing that spread fires were more economical besides having enormous tactical advantage.

Mr. Lewis Nixon presented a resolution to the effect that papers be invited on the subject of "Life Saving at Sea," and that two such papers be selected and printed in next year's "Proceedings." Motions thanking the various officers were passed, after which the final adjournment was taken.

THE MIYABARA WATER-TUBE BOILER.

We have pleasure in illustrating and describing a water-tube boiler which has been designed and patented by Captain Jiro Miyabara, of the Imperial Japanese Navy. It will be seen from the accompanying illustrations that the boiler consists of two water walls, forming the front and back of a combustion chamber. The walls are composed of horizontal, cylindrical vessels arranged one above another, these vessels being connected together by flanged junction boxes, or, if desirable, short vertical tubes can be fitted. The upper drum in front of the boiler is made larger in diameter than the others, and serves the purpose of a steam drum. The horizontal drums at the back and front of the boiler are connected by inclined, diagonal heating tubes, extending across the combustion chamber above the fire grate. Within the horizontal water vessels, with the exception of those at the top and bottom, diaphragm plates are fitted opposite where the ends of two groups of tubes meet, and so forming a short uptake passage connecting them. The feed water is admitted to one of the top drums, and the presence of the diaphragms just described separates the descending water in the horizontal chambers from the mixture of water and steam issuing from the ends of one group of tubes and passing through the short uptake passage into the next group of tubes. In the upper or steam drum a baffle is fitted over the ends of the tubes, against which the mixed jets of water and steam issuing from the upper sets of tubes are projected, and serves to deflect the issuing water downward, allowing the steam to pass to the upper part of the steam drum, thus acting as a separator.



THE MIYABARA WATER-TUBE BOILER.

The circulation of the water is very complete, the water descending vertically through the chambers forming the end walls of the boiler, and rising gradually upwards and in a zigzag direction through the diagonal tubes across the combustion chamber. The two lower horizontal chambers are connected at their ends by pipes running along outside the boiler, with a view to equalizing the circulation in the series of horizontal chambers forming the two end walls of the boiler. Means have been provided for cleaning the whole of its interior as well as exterior parts. The horizontal chambers are each provided with a man hole and door at one end, large enough to admit a man, for the purpose of cleaning the insides of these chambers or expanding the ends of the tubes. Opposite the ends of the tubes in the front horizontal chambers are fitted small doors, through which the whole of the diagonal tubes can be thoroughly cleaned, and, if necessary, any of them can be withdrawn and replaced with the greatest facility. It will be seen that the tubes are withdrawn direct into the boiler room, so that it is not necessary to disturb any portion of the boiler, or deck or other fittings over the boiler; this is evidently a very great advantage. For cleaning the exterior of the tubes and the combustion chamber, or for use as sight holes, short tubes are fitted through the junction boxes connecting the front horizontal water chambers, through which ordinary tube brushes can be passed. The front and back of the boiler are coated with non-conducting material, and for the sides the ordinary casings are fitted, protected by brickwork and non-conducting material as necessary.

An experimental boiler to Capt. Miyabara's design has been made by Messrs. Humphrys, Tennant and Co., of Deptford Pier, and erected complete at their works. A series of trials of considerable duration has been conducted, burning coal at different rates, and satisfactory results obtained. Steam could, it was found, be raised very rapidly, and no damage whatever was done to the boiler by suddenly altering its temperature, either by opening the furnace door or blowing the water out. The results showed that the boiler was economical, especially when burning from 20 pounds to 30

pounds of coal per square foot of grate area per hour. With 20 pounds of coal per foot of grate, 11.87 pounds of water were, we are informed, evaporated per pound of coal from and at 212 degrees.—"Engineer's Gazette."

POWER FROM BLAST-FURNACE GAS.

Engineers on both sides of the Atlantic continue to discuss with interest the possibilities arising from the utilization of the waste gases of the blast furnaces. From the results of experimental trials that have been made of the method, there would appear to be no longer any question as to the practical utility of turning to useful account a large amount of power that is now wasted. An instructive example of the present state of this interesting problem is afforded by the results gained in the practical operation of a blast-furnace power gas plant at one of the largest steel works in Belgium. At these works, after a continuous operation of a year, the conclusion was found to be warranted that a gas engine with such trifling modifications as are required to adapt it to the nature of the gas, could be operated with the waste furnace gas without serious injury.

The details of this test, embracing all the conditions of the experiment, are very lucidly set forth by Professor Hubert, under whose direction they were made. Some of the more important of the results of his observations are taken from an abstract of them in "Engineering Magazine."

He finds that for every ton of pig iron there are also produced about 5,750 kilograms of gas, equivalent to about 4,300 cubic meters. A blast furnace producing 100 tons of iron per day, therefore, will produce about 18,000 cubic meters of gas per hour. Of this quantity, about one-half will be used in the hot-blast stoves, leaving about 9,000 cubic meters available for power purposes. He estimates, from the results of his observations, that the utilization of this 9,000 cubic meters in the gas engine should realize 3,000 horse power, as the value of the gas from a 100-ton furnace, which is from three to ten times the power hitherto produced by burning the gas under steam

boilers. In actual practice, about 1,800 horse power was realized, of which only 400 horse power was required for the blowing engines, leaving 1,400 horse power available for other uses, and which represents so much clear gain.

It is argued that with the progress now being made in the construction of large gas engines, it will soon be practicable to drive blowing engines with gas motive-power cylinders, thus enabling the present expensive steam-power plant to be dispensed with, the gas engines replacing the steam engines.

An extremely interesting phase of the argument presented in favor of the innovation is best stated in the words of "Engineering Magazine," as follows: "When, as is now frequently the case, the blast furnaces form part of a general iron and steel works, in which large quantities of power are required for rolling mills, forges, machine shops, etc., the power produced by the gases in excess of the furnace requirements is directly available for the other mechanical operations, thus enabling such plants to compete, so far as power cost is concerned, with the great hydraulic power installations which depend on natural sources of energy.

"The matter seems to be passing well out of the hands of the investigators into those of the constructing engineers. It is now the turn of the engine builders to produce large gas engines, especially adapted for use with lean gas, and suited for continuous heavy duty, and the part of energetic iron masters to take active steps to introduce the new system. Already, it is reported, a blowing engine to be operated by gas power is being designed for the Cockerill Company, and others should not be slow to follow."

From all that has been said above, it seems safe to conclude that the difficult pioneer work involved in the careful study of the conditions of the problem has been accomplished with results which should prove of the highest importance.—W., in "Journal of Franklin Institute."

STRENGTH TESTS OF SWEDISH IRON AND STEEL.

The excellent Swedish institution, the "Järnkontoret," which has done so much for the advancement of the Swedish iron and

steel industry, has published a number of interesting tests of Swedish iron and steel, as well as other materials. The annual production of hammered iron is about 200,000 tons, of which some 175,000 tons are Lancashire, but newer methods for the production of steel tend to decrease the output of hammered iron. Swedish hammered iron has an old-established reputation for toughness and softness, but the strength of it only amounts to 19 tons per square inch, with an extension of 30 to 40 per cent. in 8 inches. It is free from phosphorus, and stands considerable heat without being burnt. A small amount of phosphorus increases the strength to some 22.2 tons, but makes the handling more difficult. Lancashire iron is, of course, the staple article; the production of puddled iron only amounts to about 1,800 tons per annum, and it often contains some cinder. The strength of the two is about the same, 17.7 to 21 tons per square inch (similar to Yorkshire and Staffordshire iron), but the difference is made evident in the extension, a puddled-iron plate showing 17 to 30 per cent. along the fibers, but only 9 to 12 per cent. crossways, whilst Lancashire plates show 20 to 25 per cent. in both directions. The corresponding figures for Yorkshire and Staffordshire iron are only 8.5 to 9.5 per cent. and 3 to 8 per cent.

Although the Bessemer process obtained its first practical development in Sweden, present extensions point more in the direction of the Martin process, the former installations requiring much power and capital. The Bessemer method mostly used is the acid; the same applies to works using the Martin process, only 13 out of 47 works using the basic process.

The following table shows the various percentages of carbon which have been proved suitable for various applications.

When the percentage of carbon is—

0.0 to 0.9,	it can be welded with sand.
0.9 to 1.1,	it can be welded with borax.
1.1 to 1.3,	it can be welded with difficulty.
1.3 to 1.5,	it cannot be welded at all.
0.40,	it can be hammered at 1,000 centigrade.
0.65,	it can be hammered at 950 centigrade.
0.90,	it can be hammered at 900 centigrade.
1.10,	it can be hammered at 850 centigrade.

1.30, it can be hammered at 800 centigrade.
1.40, it can be hammered at 750 centigrade.
0.40, hardening temperature, 850 centigrade.
0.90, hardening temperature, 800 centigrade.
1.40, hardening temperature, 750 centigrade.
0.10 to 0.25, suitable for boiler plates and ships' plates, ordinary rough smith's work, etc.
0.10 to 0.30, suitable for welded carriage axles.
0.30 to 0.50, suitable for whole carriage axles, stiff and strong machine parts, etc.
0.15 to 0.30, suitable for boiler tubes.
0.30 to 0.50, suitable for bicycle tubes.
0.00 to 0.15, suitable for ordinary wood screws, cut nails.
0.00 to 0.10, suitable for telephone and telegraph wires.
0.10 to 0.25, suitable for wires, ropes for ships' rigging.
0.25 to 0.35, suitable for rope of unhardened wire.
0.45 to 0.65, suitable for rope of hardened wire.
0.65 to 0.75, suitable for rope for elevators.
0.75 to 0.90, suitable for wire for musical instruments.
0.50 to 0.75, suitable for springs, which are hardened in water.
0.75 to 0.90, suitable for spiral springs.
0.90 to 1.00, suitable for surgical knives.
1.25 to 1.35, suitable for razors.
0.50 to 0.60, suitable for circular saws for hot iron.
0.80 to 0.90, suitable for ordinary saws.
0.90 to 1.00, suitable for circular saws.
1.00 to 1.10, suitable for hand saws.
0.60 to 0.90, suitable for cabinetmakers' tools.
0.70 to 0.85, suitable for chisels for cold iron.
0.90 to 1.00, suitable for axes.
1.00 to 1.20, suitable for cutters, drills, etc.
1.20 to 1.40, suitable for turning steel, planing steel, matrixes, etc.
1.35 to 1.50, suitable for scrapers to metals.

There are also separate reports of steel from different works, manufactured according to various methods, and on the whole the results appear to be fairly consistent. As regards steel manufactured after the acid Martin process, the tensile strength (the tests refer here to steel from the different works) which is called K, comes out at:

$K = 27 + 18p$ kilogramme per square millimeter, and the elongation before fracture (F standing for the elongation)

$$F = (39 - 30p) \text{ per cent.}$$

of the original length, p representing per cent. of carbon in the

steel, which in these cases had been annealed. The tensile strength increases with the percentage of carbon, whilst the elongation decreases. This, however, only applies to a percentage of carbon up to about 1 per cent., the tensile strength reaching its maximum at a slightly higher percentage of carbon, 1.1 to 1.2 per cent., and again decreasing, when the percentage of carbon becomes greater. The elastic limit (E), within the same limits, may be expressed thus:

$E = 16 + 22\,p$ kilogramme per square millimeter.

Tests with steel of same description, taken in finished rolled state, but not annealed, show as an average from four different works:

$$K = 26 + 75\,p.$$
$$F = 37 - 33\,p.$$
$$E = 14 + 36\,p.$$

It has already been stated that steel with a carbon percentage of about 1 per cent. of carbon possesses the greatest strength; with an increase of carbon the strength decreases and the elastic limit is lowered. Such steel, however, gains in hardness what it loses in strength, and is, of course, specially adapted for numerous purposes. In Martin steel rolled under heavy pressure the tensile strength rose from 61 to 71 kilogrammes per square millimeter, the limit of elasticity from 39 to 66 kilogrammes per square millimeter, whilst the elongation was reduced from 20 to 5 per cent. The rolling pressure rose from 12,000 to 67,000 kilogrammes. The percentage of carbon was 0.44 per cent., which would make K equal to 59 kilogrammes, E equal to 30 kilogrammes, and F equal to 22 per cent., and it will be evident that K and F were not materially influenced by a rolling pressure of 12,000 kilogrammes, whilst E had risen from 30 to 39 kilogrammes. It required a much heavier pressure to alter the other two values. With reference to steel used in the manufacture of common bars, the pieces for test are oil hardened, and the tests show minimum values, which give satisfaction according to contract, whilst the maximum values are considerably higher; sup-

posing the contracted figures were K 56 kilogrammes, E 30 kilogrammes and F 12 per cent., the minimum values are K 56.2 kilogrammes, E 31.4 kilogrammes, and F 12 per cent., whilst the maximum values are K 66 kilogrammes, E 39 kilogrammes, and F 21.6 per cent. Steel for rudder frames, etc., shows a minimum value of K 45 kilogrammes, E 21 kilogrammes, and F 10 per cent., whilst the maximum value is K 65 kilogrammes, E 33 kilogrammes, and F 20 to 25 per cent. With steel for anchors the figures were K 50 to 53 kilogrammes, E 22 to 29 kilogrammes, F 20 to 25 per cent. Nickel steel for a propeller, K 73 kilogrammes, E 55 kilogrammes, and F 15 per cent. Boiler plates show K 34 to 49 kilogrammes, E 21 to 29 kilogrammes, F 22 to 32 per cent. Crank axles with cranks for locomotives show K 32 to 52 kilogrammes, E 9.2 to 29 kilogrammes, F 11 to 29 per cent., and steel plate for locomotive frames K 38 to 47 kilogrammes, E 25 to 30 kilogrammes, F 23 to 28 per cent. The figures for nickel steel with varying percentage of nickel were as follows:

1 per cent. nickel K 63 kilogrammes, E 33 kilogrammes, F 12 per cent.
2 per cent. nickel K 78 kilogrammes, E 44 kilogrammes, F 11 per cent.
4 per cent. nickel K 96 kilogrammes, E 45 kilogrammes, F 7 per cent.

Chrome steel with 1.5 per cent. chrome showed:

K 110 to 120 kilogrammes.
E 47 to 54 kilogrammes.
F 2.4 to 6 per cent.

Wire of crucible steel, finished drawn, but unhardened, showed:

K 80 to 98 kilogrammes.
E 67 to 88 kilogrammes.
F 0.7 to 2.3 per cent.

The percentage of carbon was from 0.76 to 1.45 per cent. Galvanized telegraph wire showed:

K 79 kilogrammes.
E 45 kilogrammes.
F 8 per cent.

—"Engineering."

COALING AT SEA.

The "Temperley Conveyor," here illustrated, was used in last Summer's maneuvers of the French squadron most successfully. By its means the collier, formerly the transport *Japan*, was able to transfer coal to the ships of the fleet while steaming at a speed of 10 knots; this being one of the most interesting features of the maneuvers.

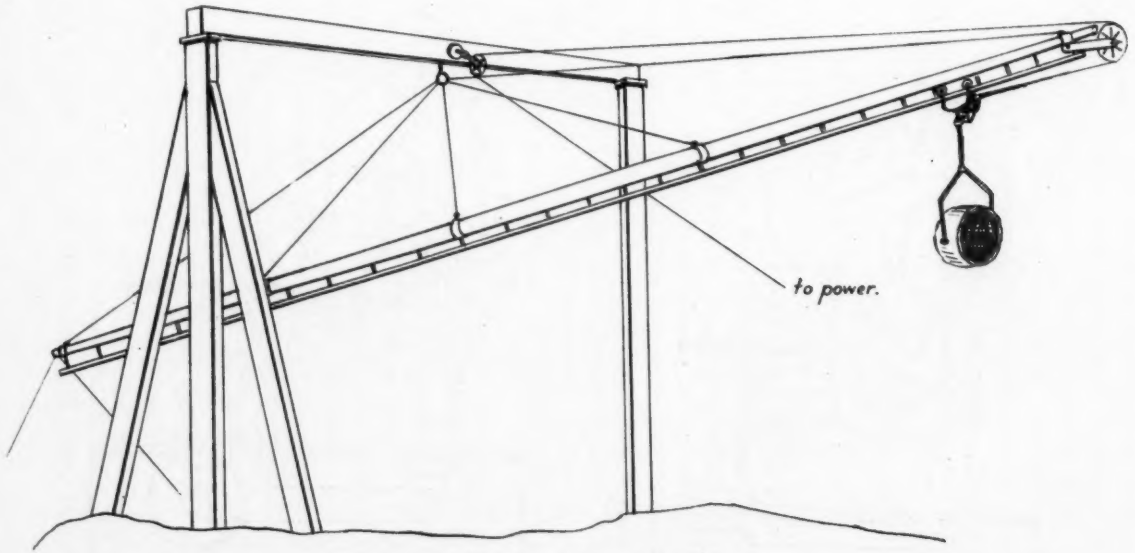
The "Temperley Conveyor" is essentially a spar suspended by a suitable hook to rigging or frame-work supports, and "guyed" in any desired position. Suspended from the under side of this spar, by rigid connections, is a track upon which runs a traveler or carriage containing the locking and detaching device shown in the detail figures. This device is very simply, yet extremely ingenious, and has for years been in successful use. Stops are located on the track wherever needed, and these, by engaging the projection on the cam *c* (as shown in Fig. 2), the mechanism is instantly thrown into the position shown in Fig. 3, and the load made free to descend.

The beauty of the device lies in its simplicity and the arrangement by which the *load* is absolutely locked while traveling along with the carriage, and yet as soon as the point for descending is reached the load is free to descend while the *carriage* is at once firmly locked in place, remaining so until the bucket hook is again hauled fully up into position, which at once acts to free the carriage for its return trip. A little study of the figures will enable any one to understand how perfectly automatic the arrangement is and how all the motions are operated by the single rope which runs from the power to the carriage pulley.

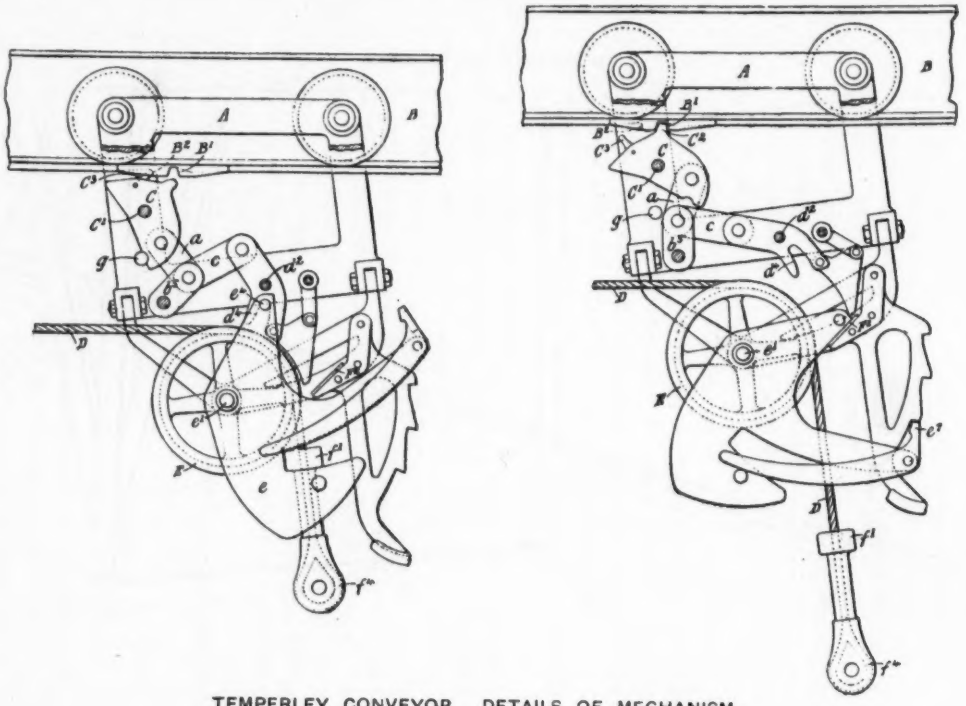
On ship board, of course, the spar is kept on deck, and only slung in the rigging at times desired.—(Ed.)

THE WORK DONE IN HAMMERING.

M. Ch. Fremont has recently contributed to the Proceedings of the French Society of Civil Engineers the results of some very interesting observations on the work done by hammermen in riveting or at the forge. By means of cinemetographs he was able



TEMPERLEY CONVEYOR.



TEMPERLEY CONVEYOR. DETAILS OF MECHANISM.

to trace the full line of travel of the hammer in different cases, and to calculate the work done with considerable accuracy. The rivet hammers used weighed between 3.3 pounds to 3.7 pounds each, or 4.4 pounds with handle included. Completing the head was done with hammers weighing 9.9 pounds to 11 pounds each, these being used either "swung" or "raised." The photographs showed that on the rise the hammer moves slowly, but rapidly increases in speed on its descent. Using the heavy hammers without "swinging" them, a good striker makes 12 blows in 15 seconds, and does in this time 2386 foot-pounds of work, or 159 foot-pounds per second. This rate cannot, however, be maintained, and if the periods of rest are few and short, as in horseshoe making, the rate of work falls to 108 or 115 foot-pounds per second. On the other hand, an exceptionally good man can for a short period work at the rate of 202 foot-pounds per second. When in place of the hammer having a movement of a quadrant only, it is swung the full circle fewer blows are struck per minute, but the work done by each blow is greater. Thus with a 15.4 pound hammer about 9 blows would be struck in 15 seconds, each of which would accomplish 231 foot-pounds of work; but the rate of working falls to 137.4 foot pounds per second.

Striking a side instead of a "down" blow, an ordinary man, not specially accustomed to such work, strikes 12 blows in 15 seconds with a heavy sledge, each of which is equivalent to from 145 to 159 foot-pounds, and the rate of work is 123 foot-pounds per second. With riveters accustomed to strike in this fashion, about 10 per cent. better results are obtained. Usually, however, they use a lighter sledge, weighing about 10 pounds, and with this can strike 13 to 14 blows in 15 seconds, doing 108 foot-pounds per second. Swinging the sledge, the number of blows falls to 10 in 15 seconds, but the rate of work is unaltered, owing to the blows being heavier. When striking on a snap the rate of work is 20 per cent. less. The hand hammers used by riveters weigh 4 pounds to 4½ pounds each, and the work done per blow is 58 to 65 foot-pounds per second, 4 blows being struck in 5 seconds. Smiths using a 5½-pound hammer

strike one blow per second, and do work at the rate of 72 foot-pounds per second. In a shoeing forge the results are about 20 per cent. better. In general, it was found that with hammers weighing from 2 pounds to 15 pounds, the work done was very uniformly equivalent to that due to a fall from a height of 13½ feet. The actual work needed to close rivets by hand and machine was found to be as set forth in the following table:

Diameter of rivet.	Area.	Hand riveting.				Time taken.	Machine riveting.		
		Work done in foot-pounds.					Work done in foot-pounds.		Final pressure.
		In closing.	With snap.	Total.	Per sq. in.		Total.	Per sq. in.	
Inch.	*Sq. in.*					*Section.*			*Pounds.*
.472	.1752	144.6	622	767	4,365	12	115.7	660	45,514
.551	.2387	253.1	1,049	1,302	5,460	15	173.6	728	56,892
.629	.3116	397.8	1,591	1,989	6,380	18	238.7	764	78,227
.708	.3937	578.6	2,314	2,893	7,350	20	325.5	827	99,561
.787	.4867	831.8	3,277	4,109	8,440	25	434.0	892	120,896
.866	.5890	1,084.9	4,339	5,424	9,220	30	542.5	921	149,340
.984	.7611	1,591	6,365	7,956	10,450	40	723.3	950	192,010

—"Engineering."

MISCELLANEOUS.

BEHAVIOR WITH ELECTRIC MACHINERY.—The following advice regarding one's behavior in the presence of electric machinery or conductors will be useful in many respects to amateurs as well as to electricians. It is from "The Engineer and Iron Trades Advertiser," Glasgow, Scotland: Never touch an electric wire that has fallen down across your way while standing on the ground, as your body will become a conductor for the electric fluid to the earth unless you have rubber boots on. Linemen are sometimes seen pulling wires about, but they have insulating boots on their feet or rubber gloves on their hands. Some people, supposing these coverings to be only used for the protection against wet weather, have foolishly grasped wires and received severe shocks in consequence. Electric wires should be handled one at a time. If it is necessary to take hold of two

wires at the same time, do not do it. In handling or drawing any wire lying over any of the ordinary street wires, especially such as convey currents for electric lighting, use a dry hand-line for the purpose or grasp the wire with insulated pincers. An ordinary wire clothes-line may become the conductor of a deadly current. In a dynamo room touch not, taste not, handle not. The most inoffensive looking dish pan may strike you like a mailed hand. Nothing is safe to you here unless you know everything. Let workingmen remember that when a company has strung wires on the crossbars of poles so closely together that a man cannot move easily between them, it is better for him to come down and resign. What profiteth a man if he has a situation if his wife be a widow? Never close a circuit without giving notice to all concerned. A telegraph notice received in the back of the neck generally arrives too late to do any good. On no condition let two wires touch your body at the same time. Don't think that any wire is not dangerous. There is a difference between a gun with a cap on it and one without that can be detected with the naked eye, but a loaded wire—who knoweth it? Trimmers employed to attend to lights in public crowded thoroughfares should be sure that the current is turned off before they touch the lamp, as the step-ladders are often very high and the public object to being hit on the head by a gyrating galvanized lamp trimmer.—"Literary Digest."

CLEANING MACHINERY BY MEANS OF BLOTTING PAPER has been tried in German workshops, says "The Tradesman," Chattanooga, as quoted by "The Engineering and Mining Journal." Tow, woolen refuse, sponge cloths, jute waste, etc., are the materials usually employed for the cleaning of machines and parts of engines which are soiled by lubricating substances and dust. The better varieties of cotton waste are excellent for scouring, but the cheaper grades are charged with dust, making necessary the use of a sponge cloth specially manufactured for that purpose. In employing blotting paper for scouring purposes, not only can the use of cotton waste be decreased, but the sponge cloths can be entirely dispensed with. The German workman

formerly received on an average 250 grams of cotton waste, one new sponge cloth and one or two renovated ones, per week; now he is supplied with 150 grams of cotton waste and 8 to 10 sheets of blotting paper, at the cost of 2½ cents, or about one-third of that of the waste, etc. The paper is not only cheaper, but it cannot soil the machine with fibers and dust like sponge cloth and woolen refuse, and it is far preferable to cotton waste. Beyond this, it is not so combustible as other cleaning materials, and if it should get caught while parts of engines in motion are being cleaned it tears easily and runs no risk of drawing the hand of the workman into the machinery.

CONQUESTS OF THE AMERICAN ENGINEER.—A recent editorial in "The Engineer," London, calls attention to the fact that the importation of engineering products from this country is growing rapidly and continually. This growth is attributed largely to the superior efficiency of American machinery and of those who operate it. Says "The Engineering Magazine," October, commenting on this editorial:

"Apart from questions of cost, and the influence which economical production has on the selling price, the superior quality of the product often causes British manufacturers to use American products, when their preference otherwise would be for articles of home manufacture.

"Examples of this sort of thing are found in malleable-iron castings, which are of such a quality that the workmen themselves are openly heard to confess their preference for the American product, while at the same time the price is 30 per cent. lower than Sheffield prices.

"American steel is now being sent into Birmingham in very large quantities, where it is mainly used for bicycle work. For bicycle purposes, for nuts, screws and bolts, or for anything that can be made in large quantities by means of automatic machinery, the American steel is preferred, not merely by the manufacturer, who finds it lower in price, but generally by the workman, as its uniform temper enables him to work it smoothly with considerably less wear on the tools.

"Not only the products, but the American machines themselves, are rapidly being introduced into England, and it is impossible for any one who is in the habit of visiting the large industrial establishments of England to avoid seeing how rapidly American labor-saving machines are being utilized. Specific instances of this are constantly to be seen—instances where British manufacturers, who have been fighting all their lives against using American machines, have latterly, through failure to get what they wanted in England, been compelled to adopt foreign-made lathes and other special machines, and now say they would not be without them."

"The Engineering Magazine" closes its comment with the following quotation from "The Engineer's" editorial:

"The business of supplying these American inventions is only just beginning. It is not to the interest of British manufacturers to admit this much, but they are gradually being forced to the conclusion that there is no denying the advance of the American, both in his methods of production, his application of those methods in the use of the machinery by which they are applied, and the men by whom they are worked."—"Literary Digest."

THOS. BRENNAN, JR., in a note to the "American Machinist," makes the following very excellent suggestion for improving the shape of pig iron with a view to reducing the work of breaking it up.

In these days when facilities for turning out work, and simplicity of construction are so much considered, I am inclined to believe that an improvement might be obtained in our pig iron. At present the shape of it is very inconvenient, especially to those whose cupolas are not of sufficient capacity for them to have a man to devote his whole attention to the breaking of it. Some firms have got up devices for breaking pigs. I have seen two or three; one I remember where a weight was pulled up and held by a trip, and when released sometimes breaking the iron at the first blow, and then again often requiring several drops. The time consumed seems never to have been considered. True,

it is generally a laborer who is employed, but even so, it is hard on the man and an additional expense to the firm.

I believe it would be much easier and save much worry if some enterprising firm would devise a way to change the present shape of pig iron, which has been in use, I believe, for the past half century or longer. I would recommend the form of babbitt metal, leaving the indent sufficiently strong to still avoid breakage in handling.

One can readily imagine if made so how easily it might be broken for use, and what a saving of labor it would effect. It would only take about half an hour's time of the laborer to do what now takes him a day or more, and would permit his attention to be devoted to other work.

A SHORT TIME AGO the Russian Admiralty made an interesting experiment with cellulose made of Indian corn pith as a packing for vessels. A cofferdam 6 feet long, 6 feet deep and 3 feet broad, was packed with blocks of cellulose made from this material, which was supplied by an American company. The cellulose within the dam was compressed until it weighed 8 pounds for each cubic foot. A 6-inch solid shot was fired through the dam, striking it at a distance of about 20 inches from the bottom. The shot struck the dam at a velocity of 1,000 feet a second, and passed clear through both the iron walls and the cellulose packing. Less than ½ pound of the cellulose was carried out by the projectile. The water compartment of the dam was filled, giving a pressure of nearly 5 feet of water on the perforated surface. In just half an hour a moist spot began to show on the outer surface of the dam, but it was evident that the moisture had come along the bottom of the packing, and not through the path of the shot. In four hours no water had come through the shot's path, and only 6 gallons had passed under the packing.

JAPAN IS NOT GOING TO BE BEHIND in the matter of technical societies. There is a society for Naval Architects and Marine Engineers, another for engineers of every department, which was started about nine years ago and now has over two thousand

members, and now there is a Society of Mechanical Engineers in Japan, which at the completion of its first year has over one hundred members. The President is Mr. Bunji Mano, M. Inst. Mech. E. (Lond.), a graduate of the Imperial College of Engineering, Tokio, who has for a good many years been Professor of Mechanical Engineering in the Imperial University, Tokio. The council is largely composed of Mr. Mano's fellow students, with the addition of a few younger men who have studied in the University or in America, one of them being a member of the American Society of Mechanical Engineers.—" Engineering Gazette."

PRICES PAID FOR AUXILIARY NAVAL VESSELS.—The prices paid for American merchant vessels by the United States Government during the war with Spain, as recorded at the New York Custom House, is as follows:

Morgan Line steamships *El Sol* (auxiliary cruiser *Yosemite*), *El Rio* (auxiliary cruiser *Prairie*), *El Norte* (auxiliary cruiser *Yankee*) and *El Sud* (auxiliary cruiser *Dixie*), $575,000 each; Maine Steamship Company's steamship *John Englis* (hospital ship *Relief*), $450,000; Cromwell Line steamship *Creole* (hospital ship *Solace*), $400,000; Old Dominion Line steamship *Yorktown* (auxiliary cruiser *Resolute*), $475,000; N. Y. & Cuba Mail Steamship Company's steamer *Niagara* (collier), $200,000; Miami Steamship's Company's steamship *Merrimac* (collier, sunk in entrance to Santiago Bay), $342,000, and steamship *Menemsha* (distilling ship *Iris*), $145,000; Charles R. Flint's steamship *Nictheroy* (auxiliary cruiser *Buffalo*), $175,000; Worth & Greacen's steam lighter *Alice*, $19,000; Morgan Line tugboat *El Tora* (auxiliary gunboat *Algonquin*), $40,000; Lewis Luckenbach's tug *Edward Luckenbach* (auxiliary gunboat *Tecumseh*), $45,000; tug *Walter Luckenbach* (auxiliary gunboat *Uncas*), $75,000; Capt. Linnekin's steam lighter *John Dwight* (*Pawnee*), $25,000; Merritt Wrecking Company's steamer *J. D. Jones*, $55,000; Merritt-Chapman Wrecking Company's steamer *Right Arm* (*Pontiac*), $30,000; Standard Oil Company's tug *Atlas* (*Wompatuck*), $65,000; tug *Hercules*, $40,000; J. P. Duncan's steam yacht *Kanawha*, $50,000; M. C. D. Borden's steam yacht *Sovereign* (auxiliary gun-

boat *Scorpion*), $300,000; Pierrepont Morgan's steam yacht *Corsair* (auxiliary gunboat *Gloucester*), $225,000; H. R. Wolcott's steam yacht *Shearwater*, $26,000; M. Lewis' steam yacht *Stranger*, $75,000; D. Dows' steam yacht *Thespia* (auxiliary gunboat *Hist*), $65,000; H. A. Hutching's steam yacht *Viking*, $30,000; W. Seward Webb's steam yacht *Elfrida*, $5,000; Fred Gallatin's steam yacht *Almy* (auxiliary gunboat *Eagle*), $110,000; H. M. Flagler's steam yacht *Alicia* (auxiliary gunboat *Hornet*), $117,000; Richard Stevens' steam yacht *Aileen*, $55,000.

STEEL WORKS IN JAPAN.—Out of a total appropriation of 13,600,000 yen the Japanese have appropriated 4,000,000 yen for the establishment of steel works; of that amount 2,500,000 yen will be spent in foreign markets for machinery. According to the original program the yearly consumption of steel in Japan was estimated at 120,000 tons, and the original design was for a plant that would turn out annually about 60,000 tons. However, since the war with China the demand for steel has risen until it amounts to 240,000 tons at the present time, and the authorities have decided to enlarge the equipment of the establishment so that it will be possible to have an annual output of 90,000 tons by April, 1901, and to 180,000 tons later on. It is intended to commence with the manufacture of plates and bars, and to extend operations as the workmen become competent, until the manufacture of guns will be undertaken.—A. F. T., in "American Machinist."

SHIPS.

UNITED STATES.

Battle Ships 10, 11 and 12 (new specifications).

The Department was wholly successful in obtaining satisfactory bids under the circular* of June 26 last, modifying the proposed speed with a view to securing about 18 knots for the above-named battleships, instead of the 16 knots named in the original circular. In the new circular the steaming radius was specified not to be less than 5,432 knots at a speed of 10 knots per hour. By this wise and timely action of the Department the United States will secure three of the most effective and speedy battle ships in the world, and there is no question but that the builders will exert themselves to make these latest additions to the Navy superior in point of finish and workmanship to anything heretofore built, a difficult task indeed in the face of the excellent work already done by the same builders, but still possible. With the new specifications come certain changes in machinery and principal dimensions from the published data in the August number of the JOURNAL, which, as far as possible obtainable at this time, are here given. The contracts for the three ships were awarded as follows: *Maine*, Wm. Cramp & Sons Ship and Engine Building Co., Philadelphia, Pa., $2,885,000; *Missouri*, Newport News Ship-building and Dry Dock Co., Newport News, Va., $2,885,000; *Ohio*, Union Iron Works, San Francisco, Cal., $2,899,000.

It is to be noted from the tables that the length of these ships has been increased as well as the coal-carrying capacity. The three ships will be in no sense triplicates, owing to the builders bidding on their own plans; but, generally speaking, they will be strictly in the same category, and will embody every modern

* Vol. X, No. 3, p. 805.

improvement and point of excellence known in marine engineering and naval architecture.

General dimensions and weights of the *Maine*:

HULL.

Length on load-water line, feet	388
Length over all, feet and inches	393– 9
Breadth, molded, feet	72
Breadth, extreme, feet and inches	72– 2½
Freeboard, forward, feet	20
Freeboard, aft, feet and inches	13– 3
Freeboard, amidship, feet and inches	20– 3½
Mean draught, with 1,000 tons coal and all stores and ammunition, feet and inches	23–10½
Corresponding displacement (trial), tons	12,500
Speed per hour in knots	18
Area amidship section, square feet	1,637
Area, load-water plane, square feet	21,000
Immersion, tons per inch	52
Moment to alter trim 1 inch, foot tons	1,050
Wetted surface, square feet	35,572
Mean draught, with all provisions, stores, ammunition and 2,000 tons of coal on board, feet and inches	25– 6
Corresponding displacement, tons	13,500
Metacentric height (at 25 feet 6 inches draught), feet	4.20
Range of stability at same, degrees	68
Maximum righting arm, feet and inches	2– 5
Maximum righting moment, foot-tons	32,535
Angle of maximum righting arm, degrees	36

ARMAMENT.

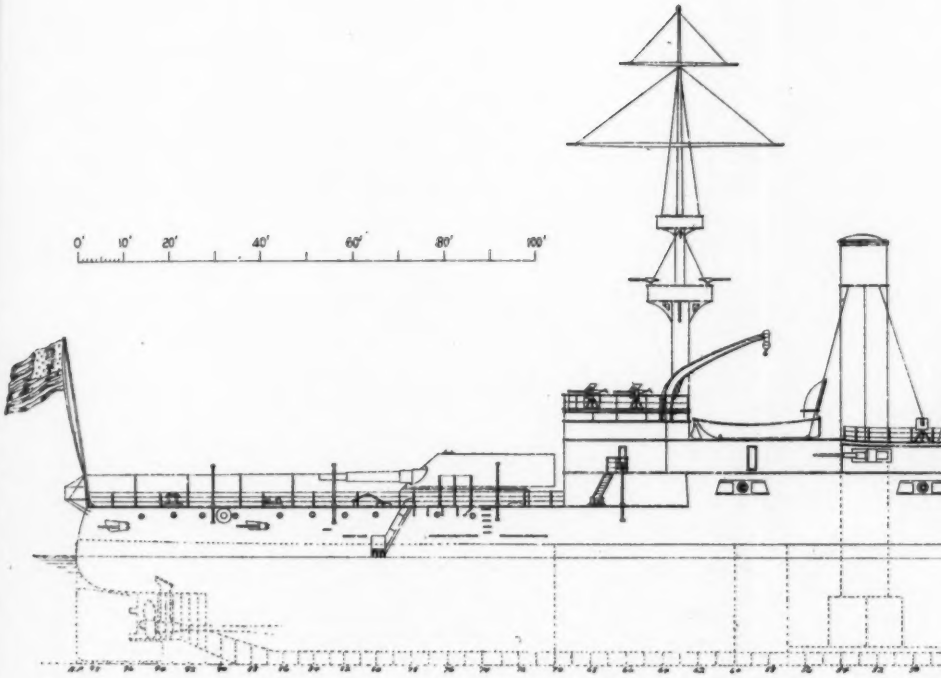
Main battery: Four 13-inch B.L.R., fourteen 6-inch R.F.

Secondary battery: Twenty 6-pounder, R.F., six 1-pounder R.F., four Gatlings, one field gun.

Height of guns above 23 feet 10½ inches L.W.L.:	
Axis of forward 13-inch guns, feet and inches	26– 1½
Axis of after 13-inch guns, feet and inches	18– 7½
Axis of 6 inch guns, main deck, feet	15
Axis of 6-inch guns, upper deck, feet and inches	22– 4½

THICKNESS OF ARMOR.

Water-line belt amidships:	
To 1 foot below 23 feet 6 inches L.W.L., inches	12
Bottom, inches	8½
Height above 23 feet 6 inches load line, feet and inches	3– 6
Total depth of belt, feet and inches	7– 6



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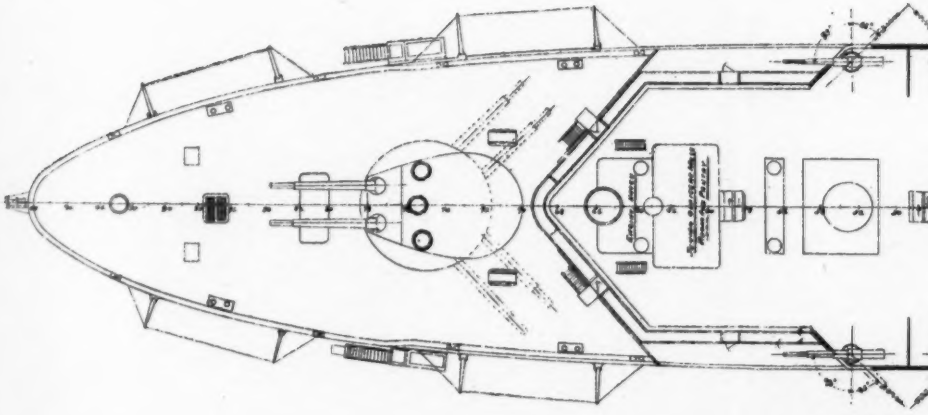

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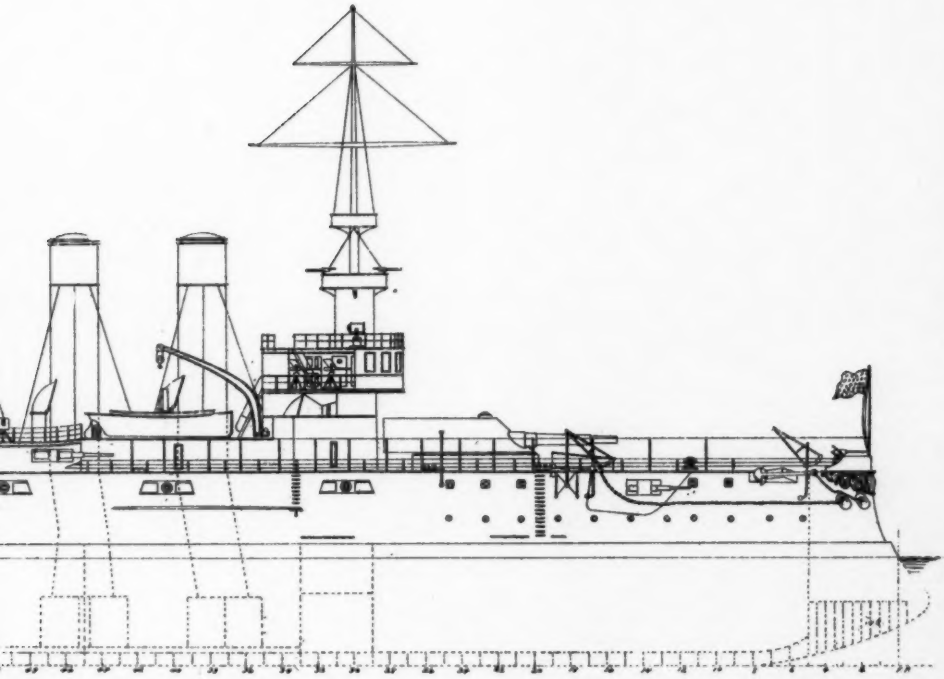

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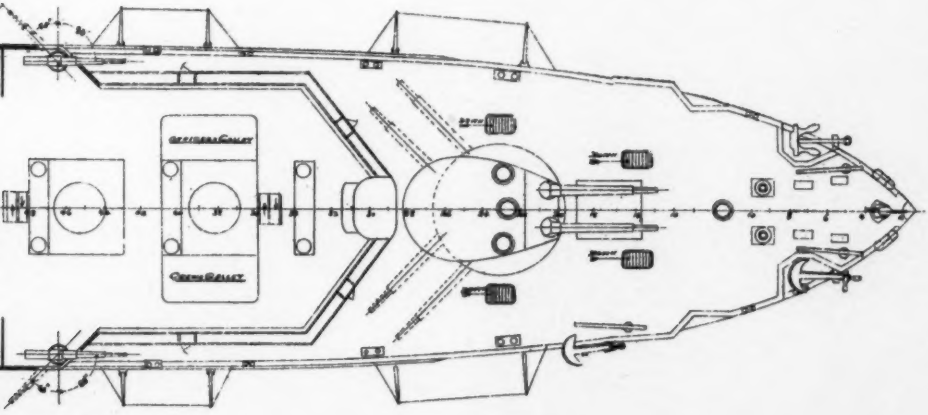


PPER DECK.

Side armor above main belt, inches	5½
Superstructure armor, inches	6
Turret armor (13-inch gun), inches	17 and 15
Barbette armor, inches	15 and 10
Protective deck armor, inches	2¾ to 4
Conning tower armor, inches	10

Machinery.—Three cylinder, triple-expansion, twin-screw propelling engines of the vertical, inverted-cylinder, direct-acting type, in two separate water-tight compartments.

Cylinders, diameters, inches	38½, 59, 92
Stroke, length, inches	42
Collective I.H.P. at 126 revolutions per minute (including main, air and circulating pumps)	16,000
Cooling surface of each main condenser, square feet	9,600
Total cooling surface, main condensers, square feet	19,200
Total cooling surface of two auxiliary condensers	1,600

The condensers will be made of composition and steel. The framing of the main engines will consist of cast-steel housings at the back and forged-steel columns at the front, following the usual general design of our large ships in this respect. The high-pressure cylinders will be forward and the low-pressure cylinders aft. Cranks, 120 degrees apart.

Boilers.—There will be twenty-four Niclausse water-tube boilers constructed for a working pressure of 250 pounds per square inch, to be reduced to 200 pounds per square inch on the steam pipes. These boilers will be in four water-tight compartments, and there will be two fire rooms in each of the main boiler compartments.

Total heating surface, measured on outside of tubes, square feet	58,104
Total grate surface, square feet	1,353

Each boiler will have 15 "elements" of 24 tubes each, this making 360 "elements" and 8,640 tubes as total.

There will be two main and two auxiliary feed pumps in each boiler compartment.

The forced draft will be of the closed fire-room system, one blower for each pair of boilers.

For trial conditions, at which an 18-knot speed must be maintained for four hours, the weights will be as follows:

GENERAL SCHEDULE OF WEIGHTS.

Hull and fittings, tons	4,836
Armor and bolts, tons	2,933
Protective deck armor, tons	600
Armament and ammunition, tons	1,058
Machinery, with water, tons	1,396
Equipment, tons	199
Outfit and stores, tons	478
Coal, tons	1,000
Total, tons	12,500

The total weight of machinery, with spare parts, etc., is not to exceed 1,500 tons.

The date of contract is October 1, 1898, and the time for completion 32 months from that date, thus bringing the date of delivery June, 1, 1901.

The details of the *Missouri*, to be built by the Newport News Shipbuilding and Dry-Dock Company, cannot be as exactly given, owing to the final specifications not being made out at this writing. The question whether water-tube boilers or Scotch boilers are to be used not being settled in the minds of the contractors. As far as known, however, we present the general features of the steam plant. There will be a difference in the diameters of the high and intermediate-pressure cylinders of the two arrangements, owing to the greater pressure to be used with water-tube boilers.

If water-tube boilers are used, the specifications now call for the following:

Two engines, right and left, in separate water-tight compartments.

Vertical, inverted-cylinder, direct-acting, four-cylinder, triple-expansion type, with 34¾-inch H.P. cylinders, 53-inch I.P. cylinders and (two) 63-inch L.P. cylinders. Stroke of all cylinders, 48 inches.

The collective indicated horse-power of propelling, air and circulating-pump engines will be 16,000 when the main engines are making about 120 revolutions per minute.

The order of cylinders, begining forward, is as follows: H.P.,

I.P., first and second low. The Stephenson link motion will be used for valve gear, with piston valves for all cylinders.

All cylinders will be steam jacketed.

The engine framing will consist of forged-steel columns front and back, braced by forged-steel tie rods.

The crank shafts for each engine will be in four sections, coupled together by flange couplings. The sequence of cranks will be, H.P., first L.P., intermediate and second low. The crank, line, thrust and propeller shafts will be made of high-grade machinery forgings, nickel-steel, oil tempered and annealed.

There will be one main and one auxiliary condenser for each main engine, with cooling surfaces of 9,400 square feet and 1,000 square feet respectively. Each auxiliary condenser will have a combined air and circulating pump.

The boilers will be of the water-tube type, having 48,000 square feet of heating surface and 1,250 square feet of grate surface. The working pressure on boilers will be 250 pounds, reduced to 200 pounds on the steam pipe.

The forced-draft system will consist of two blowers for each fire room, the blowers discharging into an air-tight fire room.

There will be four evaporators with an aggregate tube-heating surface of 1,000 square feet. If the space will permit, the evaporators will be fitted for working in multiple effect.

Reserve feed-water tanks will have a capacity of 100 tons.

If Scotch boilers are to be used, there will be changes as noted in the following abstract from the specifications, the omitted details being similar to the above:

Two engines, right and left, in separate water-tight compartments.

Vertical, inverted-cylinders, direct-acting, four-cylinder, triple-expansion-type; 36-inch H.P. cylinders, 54-inch intermediate cylinders, and (two) 63-inch L.P. cylinders. Stroke of all cylinders, 48 inches.

The collective indicated H.P. of propelling, air-pump and circulating-pump engines will be 16,000, when main engines are making about 120 revolutions per minute.

The order of cylinders will be as follows: Beginning forward, H.P., I.P., first and second L.P.

There will be two single-ended and three double-ended Scotch boilers, constructed for a working pressure of 180 pounds per square inch. They will be 16 feet 9 inches outside diameter. Each single-ended boiler will have four, and each double-ended boiler eight furnaces, 3 feet 8 inches internal diameter.

The total grate surface will be 762 square feet, and the heating surface, 26,500 square feet.

The forced-draft system will consist of two blowers for each fire room, the blowers discharging into an air-tight fire room.

There will be three evaporators, with an aggregate tube-heating surface of 600 square feet. If the space will permit of it, the evaporators will be fitted for working in multiple effect.

Reserve feed-water tanks will have a capacity of 50 tons.

The *Ohio* to be built, as stated, by the Union Iron Works of San Francisco, may be given water-tube boilers also, although specifications are only in for the Scotch-boiler arrangement. The principal data of the machinery is as follows:

Two engines, rights and lefts, in separate water-tight compartments.

Vertical, inverted-cylinder, direct-acting, triple-expansion type, four cylinders, 35½ inches H.P., 53 inches I.P. and 63 inches for two low pressures, by 48 inches stroke. Collective I.H.P. will be 14,600 at 120 revolutions per minute, with air and circulating-pump engine.

The arrangement of cylinders is as follows: H.P. forward, intermediate, first low and second low.

Stephenson link motion for valve gear, with piston valves for high and intermediate cylinders and double-ported slides for low pressure. Engine framing consists of forged-steel columns for the front and built-up columns for the back.

The sequence of cranks will be H.P., intermediate, first low and second low. The principal working parts will be of high-grade machinery forgings, nickel-steel, oil-tempered and annealed, with the exception of the main crank shaft, which will be made of nickel-steel of 80,000 pounds tensile strength. The

crank shaft will be made in four sections, interchangeable, 15½ inches diameter with 8½ inches hole; propeller shaft will also be 15½ inches diameter with 8½ inches hole.

There will be a condenser for each engine with a cubic surface of 9,000 square feet, and an auxiliary condenser with a cubic surface of 800 square feet. The main circulating pumps will be capable of lifting 12,000 gallons per minute each. There will be eight single-ended steel boilers of the horizontal, return, fire-tube type, constructed for a working pressure of 200 pounds per square inch, and two water-tube boilers, or all the boilers will be water-tube type, as yet undecided upon.

The Howden system of forced draft will be fitted to all boilers.

The total heating surface will be about 28,014 square feet, with a total grate surface of 700 square feet.

If the Scotch boilers are used, they will have an outside diameter of 15 feet 8 inches and a length of about 9 feet 11¼ inches, with four furnaces, 39 inches internal diameter.

At least three evaporators, with a total of 600 feet of heating surface, will be fitted, and, if water-tube boilers are used, four evaporators will be fitted, with a total heating surface of 1,000 square feet, and, if possible, the evaporators will be fitted for multiple effect.

The feed heaters will contain 750 square feet of heating surface each, one for each engine room.

The ice machine, of the dense-air type, will be capable of producing the cooling effect of two tons of ice per day.

If Scotch boilers are used, there will be reserve feed-water tanks of 50 tons capacity, and if water-tube boilers, at least 100 tons.

The contract price is $2,899,000.

The displacement will vary according to the type of boiler used, not yet decided.

Monitors 7, 8, 9 and 10, Arkansas, Connecticut, Florida and Wyoming.—Bids for the construction of these four harbor-defence monitors under the general specifications published in the August number of the JOURNAL, were opened at the Navy Department October 1, 1898. The bids were as follows, each being for one monitor:

Name of Bidder.	Time to complete.	Price.
Newport News S. & D. D. Co.,	27 months,	$860,000
Bath Iron Works, Bath, Me.,	27 months,	862,000
Lewis Nixon, Elizabethport, N. J.,	24 months,	825,000
Union Iron Works, San Francisco, Cal.,	27 months,	875,000
Maryland Steel Co., Sparrow's Point, Md.,	26 months,	876,000
Wolff & Zwicker, Portland, Or.,	27 months,	937,500
W. & A. Fletcher Co.,	21 months,	927,000
Columbian Iron Works, Balto., Md.,	27 months,	1,015,000
John H. Dialogue & Sons, Camden, N. J.,	26 months,	1,171,000

The awards were made as follows: *Arkansas*, to Newport News S. & D. D. Co.; *Connecticut*, to Bath Iron Works; *Florida*, to Lewis Nixon; *Wyoming*, to Union Iron Works.

Since the awarding of these bids the Department decided to issue a circular calling for an estimate of additional cost for certain modifications whereby it is hoped to increase the size and efficiency of these monitors without exceeding the appropriation. This circular has just been issued, and contains elements of design differing considerably from those called for in the original circular. The new elements of design are as follows:

Length on load-water line (normal displacement), feet,	260
Breadth, extreme, at water line, feet,	57
Mean draught at normal displacement, about, feet,	14½
Normal displacement, about, tons,	4,000
Total coal capacity, loose stowage, tons,	400

7. The hull is to be of steel, not sheathed, with double bottom, and close water-tight subdivisions.

8. One military mast is to be fitted with fighting and search-light tops.

9. The boats are to be stowed clear of the blast of the guns, and two lifeboats are to be so carried as to be quickly lowered.

10. The protection of the hull against injury to the water-line region is to be afforded by means of a side-armor belt of a maximum thickness of not less than 11 inches, and a mean depth of 5 feet. The belt to extend throughout the length of the vessel, and to maintain the maximum thickness abreast the engine and boiler spaces; from thence forward and aft it may be tapered gradually to a uniform thickness of 5 inches. The barbettes for the 10-inch guns will have armor 10 inches thick.

11. Turrets to be of the balanced type, with front plate inclined 42 degrees from the vertical. The turret armor is to be 10 inches thick.

12. A protective deck is to extend throughout the length of the vessel, to be worked flat. The total thickness will be not less than 2½ inches.

13. A conning tower of not less than 7½ inches in thickness, having an armored communication tube not less than 3 inches in thickness, will be carried in a suitable commanding position forward, the tube extending to the armor deck and affording protection to the voice tubes, bell wires, etc.

14. The vessel will be driven by twin screws. The engines (two in number) are to be of the vertical, triple-expansion type, in one water-tight compartment. The boilers (four in number) are to be of the water-tube type, constructed for a working pressure of 250 pounds, and are to be placed in one water-tight compartment.

15. There will be required the usual auxiliary machinery and work-shop tools, and space for operating the same, for use of engineer's department. Distilling apparatus and evaporators will be fitted for supplying fresh water.

16. The total coal-bunker capacity is to be such that at least 400 tons can be carried with loose stowage without trimming.

17. The total weight of propelling machinery, including engines, boilers and their appurtenances, all fixtures in engine and fire rooms, smoke pipes, distilling apparatus, stores, spare parts, heating apparatus, tools in workshop, water in boilers, condensers, pumps, pipes and stern tubes (but not including turret-turning machinery, capstan, windlass, steering gear or winches), shall not exceed 320 tons. In addition, tankage for 50 tons of water for steaming purposes must be supplied.

18. The following auxiliary machinery, in addition to that pertaining to the main engines and their dependencies, is to be operated by steam power, viz: anchor and steering engines, deck and boat winches, ash hoists, blower engines, workshop machinery, and all pumps except those worked by hand.

19. Ordnance material will be supplied by the Government, and will be installed by the contractors.

20. The battery will be composed of four 10-inch B.L. guns, mounted in two armored barbette turrets on the midship line, one forward and one aft; four 4-inch R.F. guns in broadside on the superstructure deck; and a secondary battery of seven R.F. guns.

21. The weight of this battery of guns, with their mounts and carriages, will be about 263 tons. The weight of the ammunition required will be about 113 tons, occupying about 3,500

cubic feet contents, in addition to the appliances and room for handling and stowing it.

22. The complement of officers and crew will be about 168.

23. Provisions and small stores are to be carried for two months. The allowance of fresh water to be carried shall be sufficient for five days. Clothing, contingent and small stores to be carried in sufficient quantities for the service of the ship for six months.

24. The electric generating plant is to consist of six units, each unit to have an engine, dynamo, and combination bedplate, and each dynamo a rated output of 400 ampères at 80 volts. The total weight of the six units complete must not exceed 60,000 pounds. The total weight of the whole electric installation, including dynamos, engines, bedplates, all fittings, wiring, stores, and two search lights, must not exceed 60 tons.

25. The turrets are to have electrical turning gear, to be furnished and installed complete by the contractors. The turret ammunition hoists, elevating gear and rammers will be supplied by the Government. They are to be operated by electricity; the motors and controlling gear for this purpose to be supplied and installed by the contractors.

26. Ammunition hoists, in addition to those above enumerated, are also to be operated by electricity; the motors and controlling gear therefor to be supplied and installed by the contractors.

27. SUMMARY OF PRINCIPAL WEIGHTS.

	Tons.
Guns and mounts,	263
Ammunition and ordnance stores,	122
Machinery, complete,	320
Water for steaming purposes,	50
Equipment, complete,	125
Boats and outfit,	12
Officers, crew, and effects,	15
Miscellaneous stores and potable water,	44

28. Two-thirds of the ammunition and stores, 10 tons of water for steaming purposes, and 400 tons of coal must be carried at the normal displacement.

29. If, on trial, the average speed shall equal or exceed a speed at sea of 12 knots an hour for two consecutive hours, the vessel will be accepted so far as the speed is concerned. If the speed falls below 12 knots and exceeds 11 knots an hour the vessel will be accepted at a reduced price, the reduction being at the rate of $5,000 a quarter knot deficiency of speed from 12 knots to 11½ knots, and at the rate of $10,000 a quarter knot deficiency of speed from 11½ knots to 11 knots. If the speed falls below 11

knots an hour the vessel may, in the discretion of the Secretary of the Navy, be rejected, or accepted at a reduced price to be agreed upon between the Secretary and the contractors. In case of rejection, any money that may have been paid to the contractors on account shall be refunded.

The propelling machinery will consist of twin-screw, vertical, triple-expansion engines of 3,200 I.H.P. The cylinders are 18 inches, 33 inches and 46 inches diameter, by 24-inch stroke, working at 200 revolutions and 200 pounds steam pressure. There will be a condenser for each engine with 2,140 square feet of cooling surface. There will be four water-tube boilers with an aggregate grate surface of about 264 square feet, and heating surface of about 11,600 square feet. The forced draft will be of the closed fire-room system. The working pressure will be 250 pounds, reduced to 200 at the engines. The general details of the specifications are similar to those for the battle ships.

Bids for the construction of the sixteen new Torpedo-Boat Destroyers and twelve Torpedo Boats, as specified in the August number of the JOURNAL, were opened in the Navy Department and awards made as follows:

No. of vessel.	I.H.P.	Speed.	Design.	Name of Contractor.	Price of each boat.
Torpedo-boat Destroyers.		*Knots.*			
1, 2 and *3*	8,000	28	Department's.	Neafie & Levy.....	$283,000
4 and *5*	8,000	28	Department's.	Wm. R. Trigg Co., Richmond, Va.	260,000
6 and *7*	7,200	29	Contractors'...	Harlan & Hollingsworth.	291,000
8 and *9*	8,400	30	Contractors'...	Fore River Engine Co..	281,000
10, 11 and *12*	8,000	28	Department's.	Union Iron Works.....	285,000
13	8,000	29	Department's.	*Gas Engine & Power Co.	282,000
14, 15 and *16*	8,300	30	Contractors'...	Maryland Steel Co.....	286,000
Torpedo boats.					
24, 25 and *26*	4,200	28	Contractors'...	Bath Iron Works,.....	161,000
27 and *28*	3,000	26	Department's.	Geo. Lawley & Sons, South Boston.	159,400
29 and *30*	3,500	26	Contractor's...	Lewis Nixon.....	165,000
31, 32 and *33*	3,000	26	Department's.	Wm. R. Trigg Co,.....	129,750
34	3,000	26	Department's.	Columbian Iron Works.	168,000
35	3,000	26	Department's.	Gas Engine and Power Co.	146,000

*Gas Engine and Power Company and Charles L. Seabury Company, Consolidated, Morris Heights, N. Y.

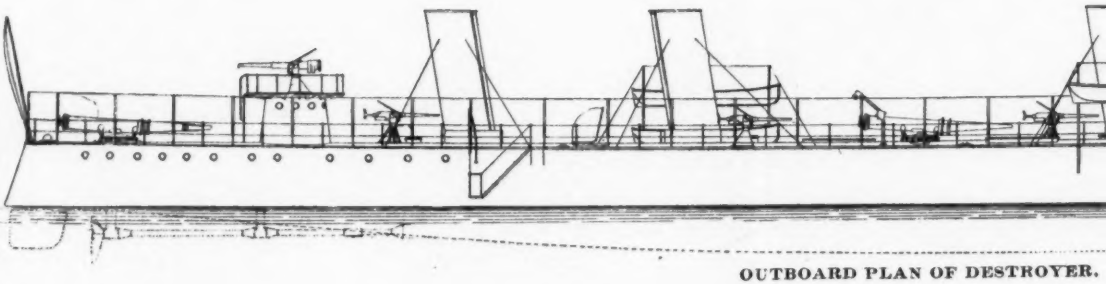
The time for delivery has been named by the contractors at twelve months from date of contract for torpedo boats, and at eighteen months for the destroyers, except in the case of *Destroyer No. 13*, where the time is only seventeen months from contract date. This contract being one of the first signed (September 30, 1898), it is probable that the contractors (Gas Engine and Power Co.) will give the *Stewart* the honor of leading the new class of vessels into the service of the United States. Her speed, it is noted, is 29 knots, guaranteed. The highest guaranteed speed is for the *Destroyers 14, 15* and *16*, being 30 knots.

The tonnage as contracted for ranges from 157 to 170 tons for the torpedo boats and from 400 to 433 tons for the destroyers. The smallest boats (*24, 25, 26*) are being built by the Bath Iron Works and have the highest speed for the class—28 knots.

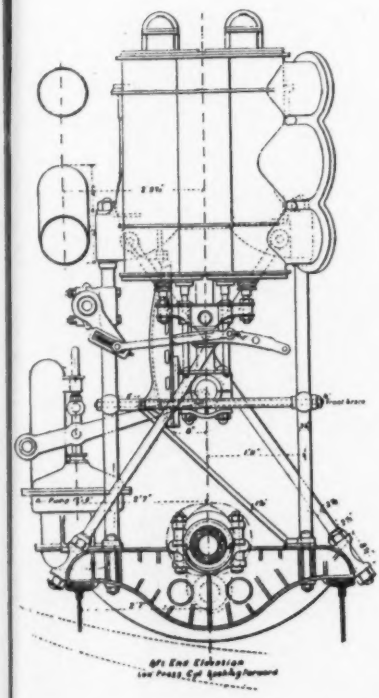
Illinois.—This 16-knot battle ship was successfully launched at the yard of the Newport News Ship-building and Dry Dock Company on October 4. Her full description will be found in Vol. VIII of the JOURNAL. The principal dimensions are: Length on L.W.L., 368 feet; greatest beam, 72 feet 2½ inches. Displacement, with two-thirds of both ammunition and stores on board, is 11,525 tons. The engines are of 10,000 I.H.P., at 120 revolutions. The date for completion is September 26, 1899.

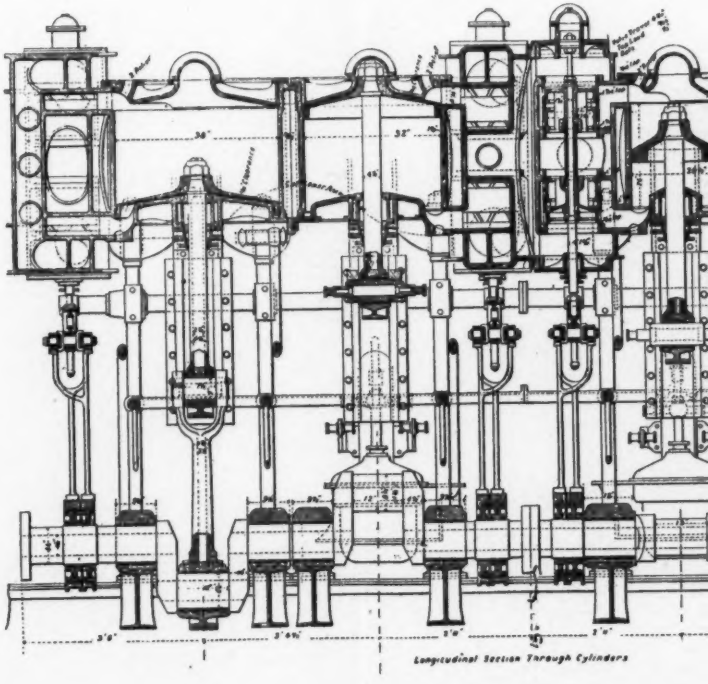
The **Farragut, Torpedo Boat No. 11.**—The ninth attempt to make the contract speed with the *Farragut* was on November 10, over a course in San Francisco waters from Hunter's Point to Pinnole Point. The depth of water varies, and influenced the results whenever there was less than about 15 fathoms. The trial was one of thirty minutes each way, and for the first half hour the speed averaged 29.34 knots, while for the second half hour the speed averaged 30.19 knots. Average of the whole hour's run was 29.73 knots, being slightly more than a quarter of a knot below the contract speed. In the contract for the *Farragut* the vessel must make 30 knots or will be rejected. The machinery functioned well, and, in deep water, it appears that she can make the full speed required. The revolutions of the screws averaged for the first half hour 404.97, and for the last half hour 419.86.

NEW TORPEDO BOAT DESTROYERS FOR T



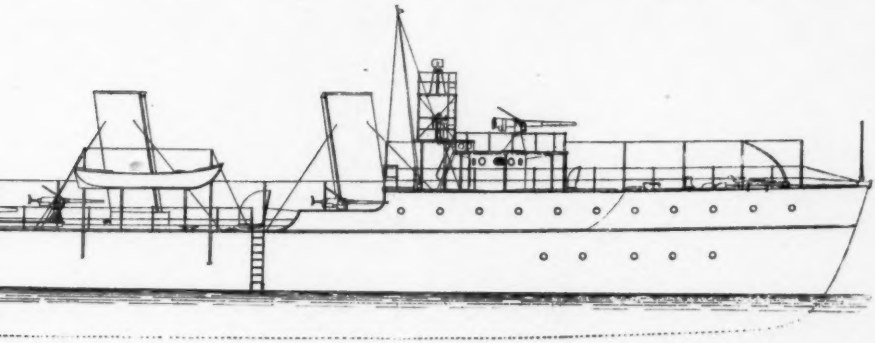
OUTBOARD PLAN OF DESTROYER.



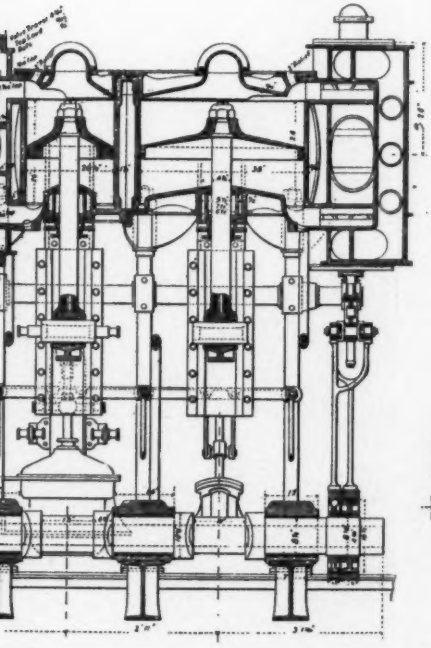


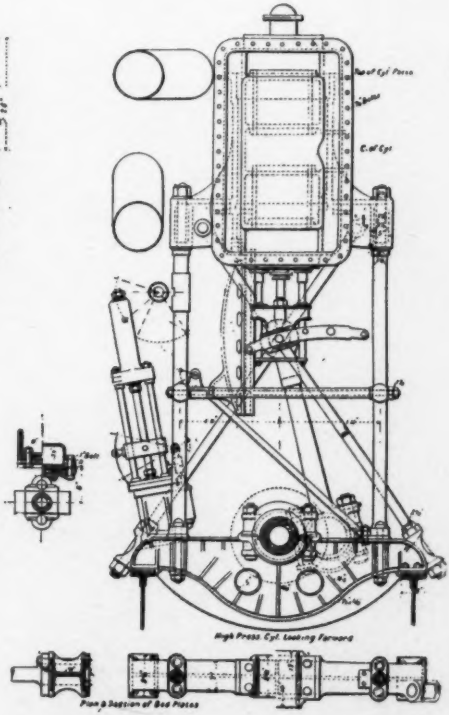
ENGINES FOR THE TORPEDO BOAT DESTR

OR THE UNITED STATES NAVY.



STROYER.





T DESTROYERS.

Davis.—The sad accident which occurred during the official trial of this torpedo boat on October 20, and which resulted in the death of seven men (the entire force in one fire-room), was due to low water and the pulling out of ten tubes from the upper drum of the forward boiler when overheated. It is said that the men were in the act of firing when the accident occurred.

It is to be noted that all the tubes of this (Thornycroft) boiler that pulled out or started, were in the second and third rows from the top. Ten tubes pulled entirely out and seven were found partly out; also a cluster of tubes loose to the hammer test in same rows adjacent to the started tubes. Repairs, however, have been completed, and a successful two-hours' run made November 24, exceeding contract requirements. Details of this will be given in next issue.

Vessels Under Construction.—

Battleships.

5	*Kearsarge*	16	knots	Newport News.
6	*Kentucky*	16	knots	Newport News.
7	*Illinois*	16	knots	Newport News.
8	*Alabama*	16	knots	Cramp & Sons.
9	*Wisconsin*	16	knots	Union Iron Works.
10	*Maine*	18	knots	Cramp & Sons.
11	*Missouri*	18	knots	Newport News.
12	*Ohio*	18	knots	Union Iron Works.

Sheathed Cruiser.

	Albany	20	knots	Armstrong's, England.

Monitors.

7	*Arkansas*	12	knots	Newport News.
8	*Connecticut*	12	knots	Bath Iron Works.
9	*Florida*	12	knots	Lewis Nixon.
10	*Wyoming*	12	knots	Union Iron Works.

Torpedo-Boat Destroyers.

1	*Bainbridge*	28	knots	Neafie & Levy.
2	*Barry*	28	knots	Neafie & Levy.
3	*Chauncey*	28	knots	Neafie & Levy.
4	*Dale*	28	knots	Wm. R. Trigg Co.
5	*Decatur*	28	knots	Wm. R. Trigg Co.

6	*Hopkins*	29	knots	Harlan & Hollingsworth.
7	*Hull*	29	knots	Harlan & Hollingsworth.
8	*Lawrence*	30	knots	Fore River Engine Co.
9	*Macdonough*	30	knots	Fore River Engine Co.
10	*Paul Jones*	29	knots	Union Iron Works.
11	*Perry*	29	knots	Union Iron Works.
12	*Preble*	29	knots	Union Iron Works.
13	*Stewart*	29	knots	Gas Engine and Power Co.
14	*Truxtun*	30	knots	Maryland Steel Co.
15	*Whipple*	30	knots	Maryland Steel Co.
16	*Worden*	30	knots	Maryland Steel Co.

Torpedo-Boats.

8	*Rowan*	26	knots	Moran Bros.
9	*Dahlgren*	30	knots	Bath Iron Works.
10	*T. A. M. Craven*	30	knots	Bath Iron Works.
11	*Farragut*	30	knots	Union Iron Works.
12	*Davis*	22.5	knots	Wolff & Zwicker.
13	*Fox*	22.5	knots	Wolff & Zwicker.
17	*Mackenzie*	20	knots	Chas. Hillman Co.
19	*Stringham*	30	knots	Harlan & Hollingsworth.
20	*Goldsborough*	30	knots	Wolff & Zwicker.
21	*Bailey*	30	knots	Gas Engine and Power Co.
24	*Bagley*	28	knots	Bath Iron Works.
25	*Barney*	28	knots	Bath Iron Works.
26	*Biddle*	28	knots	Bath Iron Works.
27	*Blakely*	26	knots	Geo. Lawley & Sons.
28	*De Long*	26	knots	Geo. Lawley & Sons.
29	*Nicholson*	26	knots	Lewis Nixon.
30	*O'Brien*	26	knots	Lewis Nixon.
31	*Shubrick*	26	knots	Wm. R. Trigg Co.
32	*Stockton*	26	knots	Wm. R. Trigg Co.
33	*Thornton*	26	knots	Wm. R. Trigg Co.
34	*Tingey*	26	knots	Columbian Iron Works.
35	*Wilkes*	26.5	knots	Gas Engine and Power Co.

Training Vessel for Naval Academy.

	Chesapeake	Sailing vessel	Bath Iron Works.

Submarine Torpedo-Boat.

1	*Plunger*	8	knots	Columbian Iron Works.

Tugs.

6	*Penacook*	12	knots	Navy Yard, New York.
7	*Pawtucket*	12	knots	Navy Yard, Mare Island.

ARGENTINA.

New Cruisers.—According to a press dispatch from Buenos Ayres of November 17th, the government of the Argentine Republic has just given orders and concluded contracts with the celebrated ship-building firm of Ansaldo & Co., of Genoa, Italy, for the construction of twelve new cruisers. The new vessels will all be of the first class, with the exception of three which will be second-class cruisers. It is not made public yet the amount which will be paid for the new men-of-war, but it is known that the Argentine government has authorized the expenditure of a large amount of money in building up its navy, which is expected to be the largest and finest of any of the South or Central American Republics.

The new cruisers will be named after the former Presidents and most prominent Generals of the country, and it is not expected that the complete order will be filled within three years. There were a number of bidders for the contract, including some firms in the United States and others in Glasgow, Scotland, but the contract was awarded to the Italian firm.

AUSTRIA.

Torpedo Boat Boa.—An unofficial trial was made recently of the first-class sea-going torpedo boat *Boa*, built by Messrs. Yarrow & Co. of Poplar to the order of the Austro-Hungarian Government. The vessel is one of four that have been constructed for the Austrian Navy at the Poplar yard, and the securing of the order in this country is satisfactory from the fact that it has been obtained in open competition with Continental yards. Some time ago the Austro-Hungarian Government asked for tenders for a single vessel of this type in order to obtain information as to the best source of supply. Ultimately two firms were selected to build such a trial vessel, Messrs. Yarrow & Co. being one and a well-known Continental firm the other. Messrs. Yarrow produced the *Viper*, which ran some very successful trials, reaching a speed of 26½ knots on a three-hours' run with a load of 26 tons on board. The results of the trial and experience with the boat since have determined the Austrian Gov-

ernment to place the order for the four remaining boats with the Thames firm, and the *Boa*, the vessel under notice, was the first to be completed. Like her three sister craft, she is 152 feet 6 inches long, and 15 feet 3 inches wide. She is constructed of galvanized mild steel, and is well subdivided by transverse bulkheads. In other respects she is of the ordinary design and construction, excepting that her scantling is somewhat heavier than is usual, the Austrian naval authorities considering it wise to sacrifice something in the matter of speed to obtain additional strength.

The armament consists of three pivoted torpedo tubes for 18-inch diameter torpedoes, two placed forward and one aft, and two Q.F. 3-pounder guns. The vessel is propelled by a set of triple-expansion engines, having three cylinders, respectively 18 inches, 26 inches and 39½ inches in diameter by 18 inches stroke. The vessel is single screw. There is one cylindrical condenser. There is the usual auxiliary machinery, such as electric-light engines, steam-steering gear, forced-draft engines, fresh-water condensers, electric ventilating fans and pumping engines. Steam is supplied by two water-tube boilers of the Yarrow straight-tube type. The propelling machinery is capable of exerting 2,000 I.H.P. The bunkers carry sufficient coal to give a radius of action of 1,500 nautical miles at 10 knots.

On her official three-hours' continuous trial the *Boa* carried a load of 44 tons and made a speed of 24.265 knots, the steam pressure being 180 pounds per square inch, and the revolutions of the engines 340 per minute. On this trial the air pressure for forced draft averaged less than an equivalent to one inch on the water gage, a moderate head which compares well with the much higher pressures needed with the former type of cylindrical boiler.

The lower speed of this vessel compared with that of her prototype, the *Viper*, is, of course, due to the additional load she carried on trial over that of the first-built craft. The question of trial loads is one which has been a good deal discussed lately in naval circles, and some authorities have come to the conclusion that contractors are let off too easily in this respect. It has

been said, and the statements were repeated during the trip of yesterday, that the 30-knot speed of the 200-feet destroyers which have been built for various naval Powers is deceptive so far as it may be taken to indicate the active service speed of these vessels, because the 35 tons load which is imposed on their trials is not nearly sufficient to represent the armament and gear which a destroyer would have to carry on active service. However this may be, it is well known that these craft seldom, if ever, realize their trial speeds when in commission and fitted as they would be for actual service. To bring this comparison to actual figures it is pointed out that if the *Viper*, carrying 26 tons, made 26½ knots, a destroyer of three times the displacement and three times the power should be loaded with 78 tons, under which conditions her speed would fall to about 27½ knots, so that there would only be one knot difference between the two vessels. As a matter of fact, however, it is considered desirable to give this first-class torpedo boat the same torpedo armament as a destroyer, although the gun armament is heavier in the latter. As it has been decided to give the torpedo boat a heavier proportionate armament, she should carry a heavier proportionate trial load in order to represent service conditions, and the naval designer must face the fact that in order to get a cheaper boat with a smaller crew he must sacrifice speed, supposing the heavy armament to be needed. A torpedo boat such as the *Boa* would cost only about one-third as much as the destroyer, and would probably carry ten or a dozen fewer men—say, 30 for the torpedo-boat and 50 for the destroyer—although the complements differ somewhat widely with the various countries and under varying conditions. The subject, however, is one which should be treated quantitatively, and it would seem that a good case has been made out for increasing the trial load on destroyers.—"Engineering."

ENGLAND.

Formidable.—This 15,000-ton battle ship was launched successfully at Portsmouth, England, on November 17.

New Battleships.—The new battle ships, provided for in this year's estimate, of the same type as the *Formidable*, will be

named as follows: *London*, to be built at Portsmouth; *Venerable*, to be built at Chatham Dockyard; *Bulwark*, to be built at Devenport Dockyard.

H. M. S. Terrible.—The series of important trials which were arranged for by the Admiralty, as the outcome of discussion in the House of Commons, with the view not only of confirming the known qualities of *H. M. S. Terrible* under service conditions, but also of accustoming the staff to the working of the machinery, has been concluded this week, when the gun and torpedo trials were made in Bantry Bay, and it is therefore convenient to review the results, which are specially interesting. They set at rest many fears as to the efficiency of the ship, for, as we shall show, the defects which discovered themselves in the boilers were inconsiderable, and the engine difficulties, of which so much has been made, have been tackled with characteristic courage and ability by the engineering staff at Whitehall. These difficulties were not altogether unexpected, and the provision made in the design enabled such changes to be carried out as effected the cure. But it may be best to describe the incidents in chronological order, as the details may best be followed in this way.

The Table accompanying this article gives in convenient form the principal results. The first trial, of 60 hours' duration, was run in May, and was at about 5,000 horse power. Twenty of the 48 boilers were in use, and the results generally agree with those on the contract trial at the same power in August of 1896. The speed in all cases is, of course, affected by the greater draught, for on the contract trial the ship only carried her normal coal supply—1,500 tons. On the later trials she started with nearly 3,000 tons, with the result that the mean draught was 12 inches to 15 inches greater. This had also the effect of reducing the number of revolutions for a given power; but with these exceptions the results agree sufficiently to render it unnecessary to make comparison. The point perhaps on which most interest may center has reference to coal consumption. On the trial, when 5,084 indicated horse power was developed at 64 revolutions, the rate was 2.3 pounds of fuel per horse-power hour; but the auxiliary machinery requires nearly 20 tons per

day, and this, out of the 125 tons per day burned on the trial, makes a big proportion of 2.3 pounds; there is, however, scarcely any need to offer such an explanation to our readers. It should, however, be stated that the coal used was from the ordinary stock supplied to vessels in commission, and not the specially hand-picked trial coal. Indeed, it was the fag end of the heap at Portsmouth that was used for most of the trials, and much of it had lain in the open, exposed to weather for years.

The second trial was made to Gibraltar, and on this occasion the First Lord of the Admiralty, Mr. Goschen, and the Civil Lord, Mr. J. Austen Chamberlain, M. P., went with the *Terrible*. The run out was made under easy steaming conditions. Thirty-two of the 48 boilers were in use, and the mean power was 10,246 indicated horse power for 81.26 revolutions, the speed of the ship being 17 knots, while the coal consumption was 1.89 pounds. Here it may be noted that in all the 60-hour trials cards were taken every four hours to determine the power, but the engines were kept running as near to the revolutions for the given power as vigilance could insure. The coal was weighed out in bags, and the figures were checked as to the quantity remaining at the end of the trial.

The ship was to return from Gibraltar with the engines making 15,000 indicated horse power, which necessitated running them at from ninety-two to ninety-three revolutions. After six hours this had to be stopped for several reasons, and even now one hears reverberations of the whirlwind which the slow speed of the *Terrible* raised. We refrained from referring to the subject because it is more interesting to study any defect in the light reflected by the means used in overcoming it. There were signs of grit coming through the cylinders, which was afterwards found to be due to the new piston rings wearing themselves down to a surface. And further, the vibration at ninety-two to ninety-four revolutions was excessive. The topmast backstay was carried away and the foretopmast "wobbled" considerably. Although this condition was experienced between ninety-two and ninety-four revolutions, at ninety-six revolutions the vibration was sufficiently reduced to enable the ship to proceed. This amount of vibration was, of

course, not considered satisfactory, and steps were taken to reduce it.

We have stated that the difficulties were not altogether unexpected. In the original design the number of bolt holes to each crank coupling was purposely arranged to be more than absolutely necessary as regards strength—there were twelve; and they were so arranged that various alterations in the angle of the cranks could be made to determine the effect of vibration, so as ultimately to insure as close an approximation to steadiness as is possible. Again, the arrangement of crank angles was purposely made different in the *Powerful* and *Terrible*, sister ships. Various calculations had been made at the Admiralty, which showed certain advantages with one setting, while with another setting other and quite different advantages were indicated.

It was known that the arrangement of crank setting given the *Terrible* would give very smooth-working engines, as regards uniformity of turning moments, although the forces causing vibration were known to be comparatively large; whereas, with the setting given the *Powerful*, the vibratory forces were much smaller, yet the uniformity of twisting moment was not so good as in the other case. On the original trials of the ships this was confirmed, for the vibrations of the *Terrible* at a certain speed were appreciably more than those of the *Powerful* at a corresponding rate of rotation. But as it was not necessary then to work exactly at this speed when the vibration obtained its maximum, namely, at 92 to 94 revolutions, for any period of time, it was thought that no inconvenience would be experienced in the future. On the run home from Gibraltar, at 15,000 indicated horse power, the engines making 92 to 94 revolutions, the vibration was, however, found, as we have stated, to be more than could be accepted as a permanent condition, and, as the *Powerful's* arrangement was known to be superior in this respect, the cranks of the *Terrible* were altered to that arrangement. But to actually test the one arrangement against the other, it was decided to disconnect the engines from the propellers and run the engines light with the ship in the basin, various curves of vibration and movements of the ship being meanwhile recorded.

The records were taken by a delicate vibration recorder, by which means it was found that the arrangement in test gave, with one engine moving, a maximum rise and fall of the extreme stern of the ship of 0.8 inch. With both engines moving simultaneously it was 1.7 inches—that is, about twice the amount due to one engine. This, of course, only occurred at the speed of revolution when the natural period of the ship synchronized with the working rate of the engine. But it was noticed that the starting of the engines was not quite satisfactory, and it was fully anticipated that some other sequence of the cranks would have to be arranged. To test similarly the original and another new setting, it was arranged to alter one engine back to the original condition, while at the same time the other engine was altered to a still different angle. Trials in the basin were then made with the two engines in these conditions. It was found that with the cranks set as originally fitted, the maximum rise and fall of the stern was 1.55 inches—about double that produced when the cranks were arranged as in the *Powerful*. The amount in the case of both engines working was not tried, owing to the time taken in making the necessary changes; but the results with the one engine suggested that the vibration with both running would be considerably greater than in No. 2 setting.

After further changes in crank settings, an arrangement was secured which, at dock trial, seemed to overcome all the trouble, and the ship went to sea again for her trial at 93 revolutions and 15,000 I.H.P. But, contrary to all expectations, the vibration at sea was still reported to be great; it was sufficient to shake the spindle off the fore truck, and, moreover, the starting of the engines was reported to be unsatisfactory, either due to inexperience or other cause. The Admiralty therefore decided to alter the cranks again. No time could be afforded to uncouple the engines and again fit up the vibration recorder for basin tests, as regards extent of vibration. At sea, however, no further trouble was experienced by vibration at any speed of rotation, and the last setting continues in use and gives complete satisfaction.

It is to be noted that the last arrangement of cranks on the

Terrible was as follows, the cylinders being in usual sequence on the shaft from forward, of H.P., I.P., first L.P. and second L.P. The H.P. crank was set 60 degrees ahead of the second L.P., the second L.P. 90 degrees ahead of the I.P., and the I.P. 120 degrees ahead of the first L.P., which leaves the latter, of course, 90 degrees ahead of the H.P., and this is the arrangement which is still retained. By plotting this in circle, it will be obviously peculiar, to say the least.

The arrangement of these cranks, as first tried on the *Terrible*, was as follows: The H.P. crank was placed opposite the first L.P., and the intermediate crank opposite the second or after L.P., and at 90 degrees from the first two. In the arrangement of the cranks of the *Powerful* the H.P. crank was set opposite the intermediate crank and the two L.P. cranks opposite each other, and at 90 degrees from the other two.

In the 15,000 indicated horse-power trial all the boilers were used, and while the stokeholds were open the fans were running easily. The speed, 19.6 knots, was realized without any difficulty, the ship running for thirty hours right out to the west in the Atlantic and thirty hours home, so that the log was checked by the return to the starting point. The next trial, at 18,000 indicated horse power, was equally easy of realization, the stokehold being open, and this power may be maintained so long as the supply of coal lasts. The coal was not of good quality, and clinkered badly, so that the fires had to be cleaned out every eight hours, while in the interval they had to be cleared of clinker. This made hard work for the stokers; but so well was steam kept that the last record showed 19,000 indicated horse power, the mean being 18,515. For the first thirty hours the ship steamed against a very strong wind and a heavy head sea, and on turning round there was a beam sea. The ship behaved well, rolling only 10 degrees. For the last hours of the trial the wind freshened on the bow, and reduced the mean speed, which, however, worked out to 20.3 knots, or only about half a knot less than when the vessel was carrying 1,500 tons less. The trial certainly showed that no difficulty would be experienced in crossing the Atlantic at over 20 knots speed. At the

PRINCIPAL RESULTS OF TRIALS OF H.M.S. *TERRIBLE*.

Date of trial	May 4–7, 1898.	June 25–27, 1898.	August 13–16, 1898.	August 29–31, 1898.	September 13, 1898.	September 14, 1898.
Where trial took place	Channel.	Passage to Gibraltar.	Channel and Atlantic Ocean.		Channel.	Channel.
Duration of trial, hours	60	60	60	60	8	4
Draught of water { forward, ft. in.	27–9	28–2	26–7	27–5	27–6	26–10
Draught of water { aft, ft. in.	27–5	29–5	29–4	29–6	29–6	29– 5
Steam in boilers, pounds	217	230	222	233	240	240
Vacuum in condensers, inches	26¾	26½	26	25½	25	25
Revolutions by counter	64	81.26	93.66	98.38	104.2	108.6
Average I.H.P.	5,084	10,246	15,554	18,515	23,050	25,115
Total distance run, sea miles	758.4	1,020	1,176	1,218	...	...
Average speed, knots	12.64	17	19.6	1st 30 hours = 20.1 2d 30 hours = 20.5	20.7 *	22
Total consumption of coal during trial for all purposes, tons	313.2	519	819.4	1,081	...	...
Consumption per I.H.P. per hour for all purposes, pounds	2.3	1.89	1.96	2.17	2.14	2.11
Description and quality of coal	Welsh, good but small.	Welsh, good.	Welsh, 6 to 7.	Welsh, 5 to 6, small and of fair quality.	Welsh, small.	Welsh, small.
State of sea	Slight.	Smooth.	Slight.	Moderate to swell.	Smooth.	Smooth.
Wind, force	2 to 5	1 to 2	...	5 to 6, 1st 30 3 to 2, 2d 30	1 to 2	1 to 2

* Logs incorrect, jumping out of water.

conclusion of this trial it was found that two tubes had developed small splits at the back end, and on examination they were found to have considerable deposits of saline matter. Also, owing to the displacement of some of the brickwork, too, the framework at the back of some of the boilers was injured by burning and required repairs, but these were the only defects worth noticing, and in view of the fact that during the trials the vessel traveled 6,000 miles, it must be admitted that the boilers have come out of the ordeal well.

After the long run at 18,000 indicated horse power, the eight-hours' trial at 23,000 indicated horse power, and the four-hours' test at 25,115 indicated horse power, were very easy. The indicator cards were taken every hour. The results in the table speak for themselves, but as regards speed, that must not be too explicitly accepted, as the trial was one of steaming, not of speed. The contract-trial records are accurate. The log on the eight-hours' trial was found to have too short a line for the speed, and jumped out of the water; on the four-hours' trial it was more accurate. Certainly, on the whole performance, Sir John Durston K.C.B., the Engineer-in-Chief, is to be felicitated, in view especially of the former irresponsible criticism based on inaccurate or insufficient information. We have already indicated that the First Lord showed his interest in the trials by going to Gibraltar on one of the runs. The Controller of the Navy, Admiral Wilson, C. B., was present at several of the vibration tests, which were carried out by Mr. H. J. Oram, Senior Engineer Inspector, and which it will be admitted, secured extremely interesting information. Mr. W. G. E. Macartney, the Parliamentary Secretary of the Board, was present at some of the sea trials, which were attended on behalf of the engineering staff at the Admiralty by Mr. E. Gouden, for the Steam Reserve by Fleet Engineer S. J. Watch, whilst Fleet Engineer John S. Rees and his senior engineer, Mr. Rush, were in charge of a very willing staff of engineers and stokers.—"Engineering."

H. M. S. Powerful.—An engineering correspondent in China sends us some details as to the steaming of H. M. S. *Powerful*, which are specially interesting, in view of the large volume of

criticism indulged in by many whose confidence has been in inverse ratio to their facts. Our correspondent confirms what we have stated all along, that the difficulties experienced on the voyage to China were entirely due to the main and crank-pin bearings, and that these have all been overcome. Many trials at various speeds and power have since been run and have been got through up to the date of the dispatch of the letter with complete success. On July 29 the vessel completed a 24-hours' fast run, accomplishing a distance of 472 miles, which gives a mean speed of nearly 20 knots. Considering that this had to be done in a tropical temperature, and with the ordinary coal picked up on the station, this was not bad. For a part of the 24 hours the engines were run at over 22,000 indicated horse power, and this was considered enough until the bunkers were replenished with fuel, as the vessel had had various runs before this 24-hours' spin. The subsequent run from Wei-hai-Wei to Yokohama—a distance of 1,200 miles—was done under easy steaming in 66½ hours. "The engines have worked well; there was no cause for any uneasiness of any kind, and they required very little water." There has been no trouble of any consequence with the boilers, but to prevent any magnifying of the troubles suggested, we may mention them, although under ordinary conditions they would be unworthy of notice. A few of the downcomer tubes have corroded at the top and bottom of the screwed joints, and these were easily replaced by spare tubes. One or two tubes of the forty-eight boilers were found to be laminated and were replaced. "During the whole cruise, extending over a considerable period, not a single leak of any description or any serious trouble has happened to the boilers." Our correspondent, who has made a diligent examination and has had special facilities for learning all that has passed during the cruise, is very decided in his expression of the mechanical success and workmanship of the ship and her machinery. The Captain, the Hon. Hedworth Lambton, and Fleet Engineer R. W. Edwards, and their respective staffs, are quite satisfied with their ship.

Dwarf and **Thistle.**—The London and Glasgow Engineering and Iron Ship-building Company, Limited, are preparing for

launch two gunboats, *Dwarf* and *Thistle*, also for the British Navy, of an interesting type, as they have been designed by Sir William White, K.C.B., with special reference to the requirements on river service in our distant possessions. They are of shallow draught, wood and copper sheathed, and propelled by twin screws. Their dimensions are as follows: Length between perpendiculars, 180 feet; length over all, 187 feet 6 inches; breadth over sheathing, 33 feet. When loaded they will only draw 8 feet of water, and have a displacement of 700 tons.

They are armed with one 4-inch quick-firing gun on the forecastle head, and another on a pedestal on the upper deck aft. There are also two 12-pounder quick-firing guns under the forecastle deck that can fire right ahead. On the broadside there are two more 12-pounders and six .45-inch Maxims, and on the masts there are fitted portable military tops, on which are mounted four more Maxims. It will thus be seen that these small craft will be capable of doing a vast amount of damage along a river bank, when called upon for such duty, the Maxims being specially effective against savage raids, and the 4-inch quick-firers against fortifications.

As to protection, the steering and chart houses and the bulwarks all fore-and-aft are built of bullet-proof steel, which has been tested to withstand bullets from the Lee-Metford rifle within a range of 10 feet. This is a very ample protection, as the most they will likely encounter will be the natives' rifles or spears, so that the men on board will have all the confidence afforded by a thoroughly shot-proof bulwark to protect them. The machinery, too, is protected for its entire length by a longitudinal coal bunker about 6 feet wide, the inner bulkhead of which is watertight, while the bunker is further subdivided into three watertight compartments by transverse bulkheads, all having sliding watertight doors worked from the upper deck. The upper and lower decks are completely plated over with steel and made watertight, and all openings have watertight covers, the upper deck being sheathed with teak and the lower with Dantzic deals.

The space below the lower deck is wholly occupied by the

magazines, shell-rooms, gunners' stores, electric stores, commander's and warrant officers' stores, etc., each space being a separate watertight compartment. Between the lower and upper deck, abaft of the machinery, the commander's and officers' quarters are placed, and, considering the size of the vessel, the quarters are very comfortable. Forward of the machinery the crew and petty officers are berthed in large, airy compartments.

Owing to the fact that these vessels are to be employed mostly in hot climates, everything has been done to insure a good supply of fresh air by means of skylights, fans, windsails, ventilators, etc., and in the way of all the accommodation the wood sheathing on the outside of the ship has been carried right up to the upper deck, to further protect the officers and men from the heat of the sun striking on the bare plating. There is also an ice-making machine fitted on board to provide ice, which will prove very beneficial in cases of fever, etc., as well as for preserving fresh food. The forecastle deck extends for about 50 feet from the stem, and in continuation of the same a shelter deck extends to beyond the after end of the machinery space. This deck is made up of two thicknesses of teak with felt between, and is open at the sides, being supported from the deck below and bulwarks by bulb-angle frames; this, with an arrangement of double awnings, will provide ample protection for the men when in the tropics. The forward and after peaks are fitted as trimming tanks, which will enable the vessel to get more easily over the bars or banks in the rivers. These tanks can be filled direct from the sea, and are emptied by the steam pumps in the engine room.

The vessel is also provided with a steam-steering engine placed in the engine room, and controlled from the chart house and flying bridge; and, besides this, there is a powerful hand-steering gear in the wheel house abaft the engine casing. Four boats are to be carried on the shelter deck, one of which will be a steam cutter. The sterns of these vessels present rather a novel appearance. They carry their breadth of deck well aft, and the lower part of the hull has been arched out on each side in the wake of the propellers, thus giving as much deck space

on the lower deck as on the upper. The stem, stern frame, rudder, propeller brackets and boss brackets are all of phosphor-bronze; in fact, the fittings are similar to those for the larger cruisers, the only difference being that the spaces are smaller.

The machinery, the design of which is by Mr. Wm. Morison, the Engineering Manager of the London and Glasgow Company, consists of two sets of triple-expansion, three-crank engines, and two Yarrow water-tube boilers. The diameters of the cylinders are: High pressure, 11 inches; mean pressure, 17 inches; and low pressure, 27 inches, by 16 inches stroke. The air pump is 11 inches in diameter by 6 inches stroke, and worked by levers on the high-pressure engine. The condenser is of sheet brass. The cooling surface of both condensers is 1,510 square feet. The centrifugal pump drives an auxiliary air pump, and a stop valve is fitted on the condenser to shut off the exhaust pipe from the low-pressure cylinder, so that the condenser may be used for the auxiliary engines when the main engines are not working. The auxiliary machinery consists of an electric-light installation, with Siemens' dynamos and Belliss' engines; a distilling plant by Messrs. John Kirkaldy, Limited, London; the ice-making apparatus by the Haslam Foundry and Engineering Company, Limited, Derby; and the feed, fire and bilge engines are of the manufacture of Messrs. G. and J. Weir, Limited.

The boilers, which are made by the builders, are of the Yarrow type. The heating surface is 4,000 square feet, and the grate surface 80 square feet. The boilers have been made of ample size, as wood fuel will be used. The engines and boilers are of the express type for a moderate power. The working pressure of the boilers is 250 pounds, reduced to 215 pounds at the engines. Cockburn's reducing valves are used throughout, and Thornycroft's feed regulators are fitted to each boiler.—"Engineering."

Hyacinth.—The London and Glasgow Engineering and Iron Ship-building Company, Limited, Govan, launched on October 27, the twin-screw, wood-sheathed, steel-protected cruiser *Hyacinth*, built for the British Admiralty. This vessel is of the improved *Dido* and *Isis* type (both of which the firm built two years ago),

and is of the following dimensions: Length between perpendiculars, 350 feet; breadth, 54 feet; and displacement, 5,600 tons on 20 feet 6 inches mean draught; and 6,360 tons displacement on 22 feet 6 inches deep mean draught; and of 10,000 indicated horse power. The vessel was designed by Sir William H. White, Chief Constructor and Assistant Controller of the Royal Navy, and has a very handsome appearance. The construction of the vessel is of the usual warship character, and the material is of Siemens-Martin steel made by the Steel Company of Scotland. There is a cellular double bottom the entire length of the engine and boiler space, and the flats of the magazines and shell rooms carry the double bottom practically to the ends of the vessel. Instead of the armor protection to the cylinders as in the *Dido* and *Isis*, the protective deck has been raised over engines and boilers, so as to completely protect them, and a considerable saving in weight has thus been effected; this has been utilized in several important ways throughout the vessel to make her more efficient. The protective deck has a thickness of 3 inches on the sloping sides, and 1½ inches in the center or flat part; this deck completely encloses the machinery, magazines and shell rooms, steering gear, and torpedo rooms, &c.

A very important addition to this vessel over her predecessors is a refrigerating plant for the preserving of fresh meat, vegetables, etc., and for making ice; this should be of immense advantage when the vessel is stationed in a hot climate. Another important innovation is the introduction of steel in place of wood in every available space, such as in store rooms, cabin bulkheads, and sundry fittings. The utility of this was specially brought out, it will be remembered, in connection with the Chinese and Japanese War, when it was found that more casualties were caused by fire and splinters from wood than by anything else. Instead of the usual wood paneling in the cabins, the steel bulkheads are paneled with ornamental asbestos covering, so that the risk of fire is reduced to a minimum. The vessel has also a much more powerful armament than the *Dido* and *Isis*, their 4.7 quick-firing guns being replaced by 6-inch quick-firing guns. There are eleven of these weapons placed in the most advantageous posi-

tions throughout the ship, besides nine 12-pounder quick-firing guns, six 3-pounder quick-firing guns, and six 45-inch Maxim guns. The six 3-pounder guns are placed in the two military tops with which the masts are fitted. There are also two 18-inch under-water torpedoes. It seems that the bow and stern above-water torpedoes are of very little value in actual warfare, and they do not appear to have been fitted in this ship.

The vessel has the usual ram bow of solid phosphor-bronze, which is carried well into the framework of the vessel. The stern post, shaft brackets and rudder, are also of phosphor-bronze, this being necessary owing to the coppering on the teak sheathing, in order to prevent galvanic action, which would be set up if steel or iron were used. The coaling arrangements also differ from those of the former ships, and as special attention has been given to the subject of coaling by the Lords of the Admiralty recently, this vessel is being specially treated in this respect, and the arrangements are not yet quite complete. Owing to the introduction of the Belleville boilers, the cross bunkers have been dispensed with, and the space thus lost has been made up for above the protective deck, so that the actual coal capacity will be rather more than in the *Dido* and *Isis*. Besides the steam-steering engines fitted in the engine rooms, there is a special compensating steering gear fitted aft under the protective deck; this gear was specially designed by the Admiralty, and was first fitted in the *Dido*, and has proved so satisfactory in her that the Admiralty have, with a few slight modifications, arranged to have it fitted in this vessel also. Messrs. Bow, M'Lachlan and Co., Paisley, are carrying out this work for the builders.

The vessel is fitted up with a complete installation of electric light, including three search lights, yard-arm reflectors, and the usual signaling lamps. The installation is in the hands of Messrs. Clarke, Chapman, and Co., Limited, who have fitted out many ships of the Royal Navy. Besides the usual bridge semaphores, the main mast is fitted with a masthead semaphore, which is actuated by means of sprocket wheels, chains and gearing from the bridge deck. The vessel will have a much bolder appearance above water than her predecessors, inasmuch as the

masts are very much loftier, and there are three large funnels in place of two. The top masts are arranged to raise and lower, and have a canting arrangement to bring them down clear of the fighting tops.

The vessel is subdivided into about 150 separate watertight compartments, the coal bunkers alone having 32 watertight compartments, which give additional security to the engine and boiler rooms, around which they are built. When the vessel is in action she will be maneuvered from the armored conning tower directly under the fore bridge. This tower is of the latest Harveyized steel, 6 inches thick, and gives protection to the steering gear, telegraphs, compass, torpedo directors, voice tubes, &c., and from the bottom of the tower to the protective deck there is an armored tube 3 inches thick, down which the telegraphs, steering shaft and principal voice pipes and bells are carried. There will be a total complement of about 500 officers and men, and the vessel is fitted up so as to act as an admiral's flagship. Everything has been done to insure the comfort of the officers and men, the officers' rooms, ward room, and gun room being large, airy, and well-furnished apartments. Special attention has been paid to the ventilation, and a thorough system of natural and mechanical ventilation has been fitted up. There are three electric-motor fans which force the fresh air down into the spaces below the protective deck, and in view of the use of lydite, the magazines and shell rooms have to be kept at a very low temperature.

The machinery consists of two sets of triple-expansion engines and eighteen Belleville water-tube boilers. Each set of engines has four cylinders, viz: one high pressure, one intermediate pressure, and two low pressure. The diameter of the high-pressure piston is 26 inches, of the intermediate pressure, 42 inches, and of the low pressure, 48 inches. The stroke is 30 inches. The revolutions at full power are 180. The two forward and the two after engines have the cranks arranged directly opposite to each other, and the cranks of the forward pair are at right angles to those of the after pair of cylinders. The low-pressure cylinders have flat slide valves, the high pressure and interme-

diate pressure have piston valves; these are worked by the ordinary type of link motion. The condensers are gun-metal castings, flat-sided, and designed to lie close in to the back of the columns, so as to save space and allow a passage at the back of the engines next the ship's side. They have a cooling surface of 9,580 square feet. The two air pumps are 24 inches in diameter by 15 inches stroke, and of the ordinary type, worked by levers from the high-pressure piston-rod crosshead. Each set of engines drives a three-bladed gun-metal propeller which runs inwards. Two-cylinder reversing and turning engines are provided for these duties. The auxiliary engines in the engine rooms include four fire and bilge pumps by Messrs. G. and J. Weir, Limited, and two main centrifugal circulating pumps, with air pump attached, by Messrs. W. H. Allen, Son and Co. These auxiliary pumps work in conjunction with the auxiliary condensers, into which the exhausts from all the auxiliary engines are led. The engine rooms are separated by a watertight bulkhead running fore and aft. Cross connections are made between all the auxiliary machinery, so that the work of each may be available in either engine room.

The boilers, eighteen in number, are of the Belleville latest type, with economizers. They are arranged in three separate boiler rooms, and are fired fore and aft. Each boiler consists of nine elements, each element consisting of seven pairs of 4-inch tubes. Each economizer consists of nine elements, each element consisting of six pairs of $2\frac{3}{4}$-inch tubes. According to the latest requirements of the Admiralty, all the tubes were prepared for the boilers in the works of the builders, special plant having to be put down for this purpose. The tubes were supplied by Messrs. A. and J. Stewart and Menzies, Limited.

In connection with the boilers, there are three main and three auxiliary feed pumps by Messrs. G. and J. Weir, Limited; six air pumps by Messrs. W. H. Allen, Son and Co., for supplying air to the furnaces and combustion chambers; six fan engines and fans by Messrs. Matthew, Paul and Co., Limited, for assisting the draft; six ash hoists by Messrs. Henry Watson and Sons; and two coal hoists by Messrs. Clarke, Chapman and Co., Lim-

ited. The boiler safety valves are loaded to 300 pounds per square inch, and the pressure is reduced in the engine room to 250 pounds by two Belleville reducing valves placed between the engines and the bulkhead valves.

We may mention that the copper work will be supplied by Messrs. Smillie and Robertson, and the telegraphs, voice pipes, &c., by Messrs. Chadburn's Ship Telegraph Company, Limited. Of the independent machinery in the ship, special reference should be made to two sets of electric-light engines and dynamos by Messrs. W. H. Allen, Son and Co.; two sets of distilling machinery by Messrs. Normandy's Patent Marine Aerated Fresh Water Company, Limited; two sets of air-compressing machinery by Messrs. The General Engine and Boiler Company; and a refrigerating plant by Messrs. The Linde British Refrigeration Company.

The **Mermaid** torpedo-boat destroyer, which has been designed, constructed, and engined by Messrs. R. and W. Hawthorn, Leslie and Co., Limited, of Newcastle-on-Tyne, for the British Government, had her maiden trip to sea on Thursday, September 1, with satisfactory results. The vessel was run at gradually increasing speeds up to a maximum of 30.875 knots, a mean speed of 30 knots being maintained for the last hour of the trial. The vessel is 210 feet in length, 21 feet beam, and 12 feet 6 inches in depth, and has machinery of 6,000 indicated horse power, steam being supplied by four water-tube boilers of the Thornycroft type. The machinery, which ran up to about 390 revolutions per minute, worked without the slightest trouble of any kind. Throughout the trial the vibration was remarkably slight, and the maneuvering qualities of the vessel proved themselves to be excellent.

The **Pegasus**, a cruiser of the *Pelorus* type, built and engined by Palmers' Company, Limited, Jarrow-on-Tyne, has completed her steaming trials. The results of the thirty-hours' coal consumption trial were as follow: Draught of water forward, 11 feet 8 inches, aft, 15 feet 7 inches; steam pressure in boilers, 261 pounds per square inch; vacuum in condensers, starboard, 25.9, port, 26.5; revolutions per minute, starboard, 175.7, port, 177.1;

horse power, 3,698; speed in knots, 17.26. The coal consumption, 216,800 pounds, or 1 96 pounds per indicated horse power per hour, was lower than that of any sister ship yet tested. The following are the results of the eight-hours' steam trial under natural draft: Draught of water, 10 feet 10 inches forward, 15 feet 2 inches aft; speed of ship, 20 knots; steam pressure in boilers, 278 pounds per square inch; air pressure in stokeholds, .86 inch; vacuum in condensers, 25.4 starboard, 26.4 port; revolutions per minute, 201.9 starboard, 204.6 port; mean indicated horse power, 2,712 starboard, 2,688 port—a total of 5,400. The contract stipulated for a speed of 18.5 knots, with 5,000 horse power. On the four-hours' full-power trial under forced draft, the results were highly satisfactory, the official record being as follows: Draught of water, forward, 10 feet 4 inches, aft, 14 feet 10 inches; speed of ship, 21.2 knots; steam pressure in boilers, 255 pounds per square inch; air pressure in stokeholds, 2.44 inches; vacuum in condensers, 25.3 starboard, 25.0 port; revolutions per minute, 210.6 starboard, 218.9 port; mean indicated horse power, 3,596 starboard, 3,538 port; total, 7,134. The contract requirements, of 7,000 horse power and a speed of 20 knots, were thus exceeded. The *Pegasus* also carried out her gun-mounting, circle-turning and stopping and starting trials, the first named being under the supervision of the staff of the Sheerness School of Naval Gunnery. The trials were an unqualified success, and the boilers (Reed's patent) did their work most efficiently. Com. Rolleston was in charge, and the contractors were represented by their manager, Mr. J. W. Reed. Mr. Howard Bone was present for the Chief Engineer of Chatham Dockyard, Mr. Pearce for the Chief Constructor, and Mr. F. Lister for the Admiralty.—"Engineering."

Cheerful.—On August 13 the torpedo-boat destroyer *Cheerful*, designed, built and engined by Messrs. R. and W. Hawthorn, Leslie and Co., Limited, ran her trial off the Tyne, when a speed of 30.64 knots was attained on the mile course, and a speed of 30 knots for the three hours. The vibration was slight, and the steaming and maneuvering powers of the vessel and the working of the machinery were excellent. The dimensions of the

Cheerful are 200 feet by 21 feet by 12 feet 6 inches, and she is fitted with four boilers of the Thornycroft type. The officials present on behalf of the Admiralty were Messrs. G. M. Apsey and H. Laughrin. Mr. Jennings, R. N., who has been appointed to the vessel, was also present.

The **Pactolus,** cruiser, completed her thirty-hours' coal-consumption trial on Wednesday evening, the 31st of August, and the official results, which have been received at Chatham, are as follows: Draught of water, forward, 11 feet 3 inches, aft, 15 feet 8 inches; speed of ship, 16.6 knots; steam pressure in boilers, 224 pounds per square inch; vacuum in condensers, starboard, 25.1, port, 25.2; revolutions per minute, starboard, 170.4, port, 172.85; mean indicated horse power, high starboard, 592, port, 603; intermediate starboard, 635, port, 579; low starboard, 626, port, 596; total starboard, 1,853, port, 1,778; grand total, 3,631; coal consumption, 2.46 pounds per indicated horse power per hour.

On the 13th of September she left Sheerness for her eight-hours' trial with the engines working at 5,000 indicated horse power. The results, which were in every way satisfactory, were as follows: Draught of water, forward, 11 feet 2 inches, aft, 15 feet 4 inches; speed of ship, 19.1 knots; steam pressure in boilers, 257 pounds per square inch; vacuum in condensers, 24.9 starboard, 25.7 port; revolutions per minute, 201.3 starboard, 194.2 port; indicated horse power, high, 887 starboard, 910 port; intermediate, 983 starboard, 859 port; forward, low, 872 starboard, 917 port; total, 2,742 starboard, 2,686 port; grand total, 5,428. The consumption of coal was not taken.

The **Diadem,** cruiser, Captain W. H. B. Graham, arrived at Spithead on Saturday morning, the 27th August, on concluding a sixty-hours' trial at three-fourths her full power, and is preparing to go on a full-power trial on Wednesday, the 7th inst. The trial that ended on Saturday was regarded as highly satisfactory. The vessel drew 25 feet forward and 27 feet 6 inches aft, and the steam pressure in the boilers was 270 pounds to the square inch with a vacuum of 27 inches starboard and 26.8 inches port. The mean collective indicated horse power for the sixty hours was

12,791, with 105.3 revolutions starboard and 105.6 port. In consequence of the inferior quality of coal, due to the strike, the consumption was slightly in excess of what was expected, but in spite of the poor quality of fuel the mean speed was 19.3 knots.

FRANCE.

Iéna.—The new first-class battle-ship *Iéna* was launched at Brest on the 1st September; the order for her construction was approved by the Minister of Marine in April, 1897, but she was not actually commenced until the 14th January last. The ship has been designed by M. Thibeaudier, Chief Naval Constructor at the Ministry of Marine, and is an improved vessel of the *Charlemagne* class, the principal improvements consisting in the substitution of 16.4-centimeter (6.4-inch) Q.F. guns for the 13.8-centimeter (5.5-inch) Q.F. guns in the earlier ships; an increase in the radius of action, and the protection of the upper works by light armor. Her principal dimension are as follows:

Length, 400 feet 9 inches; beam, 68 feet 2 inches; draught, 27 feet 6 inches; displacement, 12,052 tons; I.H.P., 15,500; estimated speed, 18 knots; normal coal supply, 850 tons; radius of action at 10 knots, 5,200 miles; coal supply, extreme, 1,100 tons; corresponding radius of action at 10 knots, 7,000 miles.

The hull is constructed entirely of steel, and no wood is to be used even in the cabins and men's mess places. Protection is afforded by a complete water-line belt with two armored decks, the one on a level with the lower edge of the belt and the other with the upper edge, while a belt of thinner armor extends from the heavy armor to above the main deck. The water-line belt is of hardened steel, provided partly by the Creusot firm and partly from the works of Marrel Bros. at Rives-de-Giers; its extreme thickness amidships is 14 inches, while it tapers off to 6 inches at the extremities; there is a 6-inch oak backing, and in the rear of that two thicknesses of ½-inch steel. The light armor is composed of two belts of 5-inch and 3-inch plates respectively, and will be carried up higher forward than it will amidships or aft; these plates are also of Creusot hardened steel. The armored tube for the protection of the voice tubes and other means

of communication will weigh 40 tons and be furnished by the Marrel Bros., as will also the conning tower, weighing 50 tons, with its hood of 1-inch steel. The armor decks will be of ¾-inch steel, which will be provided by the Guérigny firm. Cofferdams will run the length of the ship behind the light armor belt. The ship will have three screws, steam being supplied by twenty Belleville water-tube boilers fitted with economizers distributed in four stokeholds. The furnaces are arranged for using petroleum mixed with the coal. The engines will be supplied by the Forges et Chantiers de la Méditerranée; they will develop 15,000 I.H.P., giving 125 revolutions. Each set of engines will be in a separate compartment. The screws will be three-bladed, made of bronze, the diameter of the side screws being 13 feet 6 inches and of the center one 14 feet 8 inches. The following trials will have to be carried out successfully before the engines are accepted:

1. A four hours' full-speed trial with forced draft, the engines to develop 15,500 with a coal consumption not exceeding 0.94 kilogramme per H.P. per hour.

2. A twenty-four hours' trial at normal power under natural draft, the engines to develop 9,500 I.H.P., with a consumption of coal not exceeding 0.75 kilogramme per H.P. per hour.

3. A six-hours' consumption trial, all fires alight, all three screws working, with natural draft; the engines to develop 12,500 I.H.P., the consumption of coal not to exceed 0.75 kilogramme per H.P. per hour.

4. A six-hours' trial, natural draft, the engines developing 5,000 I.H.P.; the number of furnaces alight and of the screws working as the contractors choose.

In all these cases there will be a premium or penalty of 200 francs per gramme of coal in excess of or less than the stipulated quantity.

The armament will consist of four 30.5 centimeter (12-inch) guns, mounted in pairs in two turrets, one forward and one aft; the guns will be worked either by electricity or hand. With the electric fittings it is expected to be able to fire a round a minute. The secondary battery will consist of eight 6.4-inch Q.F. guns,

which will be carried in armored casemates on the main deck, as in the *Charlemagne*, four firing from ahead to the beam and four from astern to abeam; eight 3.9-inch Q.F. guns, protected by shields, four of which will be carried above the center casemates, the remaining four before and abaft the bridge. No information has yet been given as to the thickness of the turret and casemate armor, but in the *Charlemagne* it is 15.8-inch on the turrets and 3-inch on the casemates. There are also sixteen 1.8-inch and five 1.4-inch Q.F. guns, with thirteen 1.4-inch machine guns; four torpedo-tubes, of which two are submerged and two above water protected by their armor.

Comparison between the Ramillies, of the British Navy, and the Charles Martel, of the French Navy.—"Le Yacht," of July 16, has an interesting article comparing these two battle ships, of which the following is a translation:

The *Ramillies*, which was recently at anchor near our battle ships in the harbor of Ville Franche, is one of the finest fighting units of the British Navy. She is one of the seven battle ships of the *Royal Sovereign* class, which were built under the celebrated Naval Defence Act.

The *Ramillies* was built at Clyde Bank and launched in 1892. The displacement is 14,150 tons, the length, 116 meters, and the speed, from 17 to 18 knots. Not far from her was one of our finest battle ships, the *Charles Martel*, with a length of 121 meters and displacement of 11,881 tons, and a speed of 18 knots. It was an excellent occasion to study near at hand the two vessels and to compare their military value. The following is the result of our examination:

The *Ramillies* is protected by a water-line belt for a length of 74.20 meters amidships; the extremities, both fore and aft, have no protection. The maximum thickness of the belt is 457 millimeters; it is of compound plates with 150 to 203 millimeters of steel. Above, a belt of 101 millimeters in thickness protects the length of the battery; transverse bulkheads, 76 millimeters thick, offer protection against enfilading fire. The armored deck is 76 millimeters thick in the central part and descends to 91 centimeters below the water line at the side. Forward and aft it

diminishes in thickness from the transverse bulkheads to the extremities, and is only 64 millimeters thick in these regions, which have a length respectively of 23.16 and 21.94 meters. The armament consists of four 13.5-inch guns, weighing 67 tons, placed in pairs in barbette turrets on the middle line forward and aft, and of ten 6-inch R.F.G. There are also sixteen light guns of 57 millimeters, nine of 47 millimeters, and eight machine guns.

The *Charles Martel* has her water line protected from end to end by a steel belt 45 centimeters thick, diminishing to 35 forward and 31 aft; above that is a belt for the cofferdams also continuous, and of 10 centimeters thickness. The armored deck is almost horizontal, and 70 millimeters thick, upon two plates of 10 millimeters. The armament consists of two 12-inch guns and four 10.8-inch guns in closed turrets with a thickness of 30 and 40 centimeters. There are also eight 5.5-inch rapid-fire guns in closed turrets, 12 centimeters thick—this thickness including the structural plating. The light guns consist of four 65-millimeter, eight 47-centimeter and five 37-centimeter.

We shall not go into further detail. From what we have given it appears that the armament is practically equal in the two vessels, our guns making up in initial velocity what they lack in caliber. The protection is also about the same in each, but in the French vessel the protection extends from end to end, and moreover the guns are much better protected.

If we consider an encounter between these two battle ships, we have no hesitation in assigning a real superiority to the *Charles Martel*. It must be admitted, indeed, that in the commencement of an engagement, which would take place at some distance, the guns of moderate caliber would do the principal work. They would fire, by preference, shells charged with melinite or black powder, but none of these shells would be able to penetrate the belt of the *Charles Martel*.

The height of its light belt would protect the deck against the dangerous attacks of melinite shells, if the English ship had any, which is doubtful.

On the contrary, every shell fired by the *Charles Martel*, and which struck the hull of the *Ramillies* in the neighborhood of

the water line for the unarmored length of 23 meters at the bow, would make holes through which the water would pour in upon the armored deck, seriously affecting the trim of the vessel, which, possibly, would be obliged to stop her engines. A single melinite shell, well aimed at the bow, might damage the armored deck below the water line, and the consequent in-flow of water might readily bring about such a catastrophe as that of the *Victoria*.

This reasoning applies to all, or nearly all, of the English battle ships, and we believe that the best method for attacking with our well-protected ships is to fight bows on and aim at their bows, employing particularly melinite shells. Thanks to the sound policy with which we have kept our belt complete in spite of the advice of everybody, and even to the detriment of some other qualities, we have a right to count upon our battle ships and armored cruisers vanquishing a greater number of vessels, but which present one very weak point—their unarmored extremities.

Suffren.—"Le Yacht" announces that this battleship will not have Belleville boilers, as heretofore stated, but that she will be fitted out with twenty-four Niclausse boilers, having about 1,130 square feet of grate surface and 42,000 square feet of heating surface, and should develop 16,500 horse power.

ITALY.

The first-class battle-ships **Benedetto Brin, Ammiraglio** and **Principessa Elena**, which are being built at Castellmare, Spezia and Venice, respectively, will be of the following dimensions: Length, 409 feet between perpendiculars; beam, 77 feet 6 inches; displacement, 12,765 tons, with a mean draught of 26 feet 4 inches. Protection will be afforded by a water-line belt of nickel steel extending from the ram to about 50 feet of the stern; the belt tapers from 6 inches amidships to 2 inches at the extremities; the 6-inch armor amidships being carried up to the battery deck, forming a citadel, the ends of which are shut in by 10-inch athwartships bulkheads; the armored deck, extending the whole length of the ship, tapers from 3 inches to 1.8 inches. The

engines are to develop 14,000 I.H.P. under natural draft, and 18,000 I.H.P. under forced draft, to give a speed of 18 and 20 knots, respectively, steam being supplied by water-tube boilers. The normal coal supply will be 1,000 tons, which will give a radius of action of 5,000 miles at 10 knots, but in case of necessity double that amount of fuel can be carried. The armament will consist of two 30.5 centimeter (12-inch) guns mounted in a turret aft, protected by 6-inch armor of hardened steel; ten 20-centimeter (8-inch) Q.F. guns in pairs in turrets, one forward on the center line of the ship, and the other four, one at each angle of the citadel; these turrets are also protected by 6-inch armor of hardened steel; sixteen 7.6-centimeter (3-inch) Q.F., eight 3-pounder Q.F. guns, and four torpedo tubes. The principal characteristics of the new ship are the increase in the number of medium-sized and light Q.F. guns, the protection by turrets of all but the smallest guns, and the making of the stern armament of the ship heavier than that forward. It was originally intended that these ships should carry 6-inch Q.F. guns, but in view of the heavier armament being given to many new foreign ships, it was thought advisable to substitute the 8-inch guns, in view of their greater penetrating power, although the rate of fire from them is much slower than from the 6-inch; for a similar reason the 3-inch Q.F. guns have been substituted for the 2.2-inch (6-pounder) Q.F. guns which have been generally carried up to the present.

JAPAN.

H.I.J.M.S. Shikishima.—Bow Creek, which forms the tidal portion of the much-abused and almost entirely pumped-dry river Lea, has had launched upon its muddy bosom war vessels sufficient to set up any nation as a first-class naval power; for at the head of its last short bend are situated the building slips of the Thames Iron Works. On November 2, at the top of the tide, and in brilliant November sunshine, was witnessed one of the prettiest of all the successful launches carried out at this historic spot. The Japanese battle ship *Shikishima* (the accent is on the second syllable) is said to be the heaviest vessel ever launched from a slip; but this we think is an error,

for, if we are not mistaken, the launching weight of either the *Campania* or *Lucania*, if not of each, was over 9,000 tons, whilst the official figure given for the *Shikishima* is 8,250 tons, of which 7,000 tons was made up by the weight of the hull, and the remainder consisting of the launching cradles. The belt armor was not in place, but we understand some of the Belleville boilers were in position. The following are the leading dimensions of this magnificent vessel:

Length over all, feet	438
Length between perpendiculars, feet	400
Breadth, extreme, feet and inches	75–6
Depth, top of keel to upper deck, feet and inches	45–2½
Draught of water, mean feet and inches	27–3
Displacement at that draught, tons	14,850

In general constructive details the *Shikishima* follows the usual methods employed for ships of this class in the British Navy. She is built on the usual bracket-frame system with wing passages on each side to be used for holding coal. She has a double bottom amidships with water-tight flats at the ends of the vessel, thus having practically a double bottom from end to end, as is universal with ships of this class in our own Navy.

The armor is of Harveyized nickel-steel. The side protection consists of a belt which extends from stem to stern. As stated, none of this was in place at the time of the launch, except the extreme after plates. The belt is 8 feet 2 inches in maximum depth. It is 9 inches thick amidships, and tapers to 4 inches thick at the ends. It has a vertical extension of 5 feet 6 inches below the water line and 2 feet 8 inches above at the designed load draught. Above this belt, and carried to the height of the upper deck, there is side armor 6 inches thick for a length of 250 feet, thus extending longitudinally over the space between the two barbettes. Between the main and upper decks there are 12-inch screen bulkheads which join the barbettes to the side armor. The armored deck is arranged according to the modern principle, as in the ships of the *Magnificent* class, its sides being joined to the lower edges of the belt. It has sufficient curve to rise 2 feet 8 inches above the water line amid-

ships. From stem to stern it is 2½ inches thick, but an extra plate of 1½ inches thick is worked on the slope of this deck within the citadel, so that in this part the total thickness of the deck is 4 inches. The main deck is 1 inch thick within the citadel, thus adding to the protective features. The two barbettes are circular in plan, are placed with their diameters coincident with the fore-and-aft center line. The armor on them has a maximum thickness of 14 inches, and runs to a height of 4 feet above the upper deck. There are eight water-tight casemates on the main deck and six on the upper deck, all of 6-inch armor on the outside, and having armor plating at the back to protect the guns' crews from explosive shells.

The armament consists of four 12-inch breech-loading guns of 40 calibers, two being in each barbette, and fourteen 6-inch quick-firing guns mounted in the casemates referred to. There are also twenty 12-pounder guns, eight 47-millimeter, 3-pounder, quick-firing guns, and four 47-millimeter, 2½-pounder, quick-firing guns. There are four submerged discharges for 18-inch torpedoes, and one in the stem above the water line. For defense against torpedoes the usual net arrangement is provided in the design.

The vessel is, of course, twin-screw, the two sets of propelling engines being supplied by Messrs. Humphrys, Tenant and Co. They are of the usual description of battle-ship engines made by this firm, being of the three-stage compound type, with cylinders 34 inches, 53 inches and 84 inches in diameter, with a stroke of 48 inches. There are two main condensers, having a cooling surface of 15,500 square feet. There will be twenty-five Belleville boilers, having a total collective heating surface of 40,000 square feet. The designed power is 14,500 indicated horse power, and the contract speed is 18 knots.

The *Shikishima* is to be fitted as a flag ship, accommodation being provided for an admiral and thirty-eight officers. The admiral's saloon is right in the stern, his saloon opening out on to the stern gallery. Next to the admiral's quarters are the ward room and dining rooms, and beyond again are the officers' cabins. The Japanese officers, who have seen something themselves of the effect of shell fire on wooden fittings, have wisely made a point of

having as little wood as possible. The cabins are divided by galvanized corrugated steel, and, in fact, metal is substituted for wood in all positions where it is admissible. The crew are berthed forward and there is mess accommodation for the entire ship's company at one sitting. The total complement will be 741, all told.

An excellent portrait of the vessel, as she will be when completed, was presented to the guests of the company after the launch. From this it may be seen that the *Shikishima* will be a handsome vessel, bearing a strong likeness to our own recently-designed battle ships. She has three funnels and two military masts, each with fighting tops and search-light platforms at the masthead. The barbette guns have the now usual shields. Steel derricks are fitted for handling the larger boats. There will be two 56-foot vidette boats of the same type as those of the British Navy. There will also be a 42-foot steam launch, a 30-foot steam pinnace, two 30-foot cutters, and a 32-foot pinnace, three gigs respectively 32 feet, 30 feet and 27 feet, and 27-foot lifeboat, and a dinghy. There will be twelve boats altogether, and in addition a Balsa life raft.

The vidette boats are fitted with the Thames Iron Works' own type of water-tube boiler. They will each carry two fish torpedoes in the usual dropping gear, besides which there will be a 2½-pounder Hotchkiss gun in the bow. A gun of the same nature is carried in the steam launch, the 32-foot pinnace and each of the 30-foot cutters respectively. There are four improved Inglefield anchors, each weighing about 6 tons, besides which there are small anchors of the usual Admiralty pattern. The cables are 2½ inches. The steam capstans and other cable gear have been supplied by Messrs. Harfield and Co. The electric lighting will be carried out by the Electrical Department of the Thames Iron Works. The installation consists of six electric search lights, fitted with projectors 24 inches in diameter and Mangin mirrors. There are four steam-driven dynamos, three of 400 ampères and 80 volts, and one of 200 ampères and 80 volts. The steam-steering engines are in duplicate; Cameron steering gear is used. The engines are placed in a water-tight compartment, and the ship can be steered from either the flying bridge, the forward conning-

tower, the after towers, the under-deck station forward, or the steering compartments. The distilling machinery will produce 150 gallons of fresh water per hour.

It will be seen that the *Shikishima*, when completed, will be a noble addition to the Imperial Japanese Navy. In many respects she resembles closely our own *Majestics* and *Magnificents*, being even, as a ship, a trifle bigger than these enormous vessels, although displacing a little less in full sea-going trim, owing to a smaller coal capacity. The British ships have a fuel capacity of 900 tons, as against 700 tons for the *Shikishima*. If 50 tons were added to the latter, it would make the displacements equal, for the total weights are 14,900 tons for our own big battle ships and 14,850 tons for the Japanese vessel.

In comparing the designs of the *Majestic* and the *Shikishima*, the most striking feature is undoubtedly the difference in the disposition of side armor, for while in the British ship it ends at a point where the armored bulkheads are met, in the Japanese vessel the belt is carried right to the stem and stern pieces. It will, of course, be remembered that the *Majestic* design was got out long before that of the other vessel, and, indeed, it may be said that the Japanese naval officers—and the Japanese are truly the politest and best-mannered people in the world—have paid our own Admiralty officials the compliment of following British designs pretty closely. That is a fact that they themselves are always the first to acknowledge. But although the following has been close, it has not by any means been blind imitation.

Captain Miyabara, and those who worked with him in this country on the Japanese Naval Commission, have now left England to take up other duties in Japan. We may, therefore, say with the greater freedom, that not even British naval officers with a life-long experience of all that pertains to fighting ships, and brought up with the great traditions our own Navy affords, could have worked better and more successfully at mastering all the details which they had to supervise, or shown a greater determination to understand "the true inwardness" of each feature and improve upon it, if improvement were possible. It needs a very short experience of Japanese methods and ways of thought to un-

derstand why the smaller country had such an easy victory in the late war in the Far East.

The armaments in the *Majestic* and *Shikishima* are not greatly different, the chief difference being that the latter has two more 6-inch guns. The contract speed for our ships was half a knot less. The legend power of the *Majestic* class was 12,000, or 2,500 indicated horse power less than the Japanese ship, the latter having Belleville boilers as against the return-tube boilers of our own vessels. Such comparisons as these, however, lead to very little, for it is useless to attempt to appraise the value of a fighting ship—one of the most difficult tasks at the best—unless one has full knowledge of all the elements of danger and equipment.

This launch, as we have said, was in every way successful. The chairman of the company had determined, in memory of the terrible disaster that attended the launch of the *Albion*, to have as few strangers as possible in the yard, and there was, therefore, nothing in the shape of a great public function, with attendant crowds, that has generally characterized the big launches at Blackwall. Mr. Arnold Hills, on a special steamer. met the few invited guests at Westminster Bridge Pier, the start being made down river at one o'clock. The naming ceremony was performed by Mrs. Kato, and the ship slid promptly into the water.—" Engineering."

RUSSIA.

Poltava. Battle ship. Full-power trial.—The vessel left Cronstadt on the morning of September 16th for a twelve-hour full-speed trial, which was discontinued after a nine-hours' run, on account of bad weather.

During the run the engines worked smoothly without shock or heating, and the boilers easily kept an average working pressure of 125 pounds, and the vacuum in the condensers did not fall below 28 inches.

Instead of the contract stipulation of 82 revolutions, the engines maintained from 88 to 89, and developed a horse power of 11,200 (contract, 10,600), estimated from frequent indicator diagrams.

The average speed on the measured mile was 16.29, notwithstanding the very unfavorable weather.

No unusual vibration of the vessel was noticed during the trial.

A new board will be appointed to examine the condensers, interior surface of the cylinders, the boilers and all moving parts of the engines before final acceptance.

As soon as repairs have been completed on the *Peter Veliky*, the *Poltava* will be put in the Alexandroff dock in order to fit her under-water torpedo tubes.

This vessel and the sister ships were not originally designed for under-water torpedo tubes, but it was decided last summer to put them in. Each vessel will be fitted with two tubes.

Principal Characteristics of the Eight War Vessels to be Built for Russia, in France.—Eight vessels have been ordered in France. The Forges et Chantiers de la Méditerranée are to build at La Seyne a battle ship, an armored cruiser and three torpedo-boat destroyers. The battle ship (very similar to the French *Suffren* type) will displace 13,110 tons and have a length of 388 feet 8 inches, with 75 feet 5 inches beam and 26 feet draught; armament, four 12-inch breechloading, and twelve 6-inch; twenty 1.8-inch and six 1.4-inch quick-firing; engines of 16,300 horse power; speed, 18 knots. The armored cruiser will have the following characteristics: Displacement, 7,800 tons; length, 442 feet 11 inches; beam, 57 feet; draught, 21 feet 11 inches; armament, two 8-inch breechloading and eight 6-inch, twenty 2.9 inch and seven 1.8-inch quick-firing; engines of 16,500 horse power; speed, 21 knots. The three torpedo-boat destroyers will displace 320 tons, and be 185 feet 10 inches long, with engines of 5,700 horse power, to give a speed of 27 knots. A protected cruiser of the *Svetland* class is to be built at Havre, and M. Normand, of the same port, has received an order to construct two torpedo-boat destroyers of the French *Durandal* type, 300 tons and 26 knots.

MERCHANT STEAMERS.

New Atlantic Coast Steamers.—Among the finest passenger steamers now under construction in this country are the two vessels building at the yard of the Harlan & Hollingsworth Co., at Wilmington, Del., for the Merchants' and Miners' Transportation Co., of Baltimore, operating a regular passenger line between Boston, Providence, Baltimore, Norfolk, Savannah and Newport News. The new vessels will be exact duplicates of the *Juniata*, at present the finest steamer on the line.

The vessels now building will have a length on a 16-foot water line from inside of stem to inside of main post of 274 feet; beam molded, 42 feet; depth of hold from base line to third deck beams at dead flat, 26 feet; to fourth deck, 34 feet; spring of beam amidship, 10 inches on third and fourth decks and 9 inches on first and second decks. All four decks are to have steel beams. On the third deck, aft, there will be a passenger saloon with twenty state rooms, pantry and toilets. The saloon, which is to be fitted with a large, double stairway, will be 72 feet long and as wide as the vessel will admit. On the third deck, amidship, will be a house 16 feet wide by 77 feet in length enclosing machinery, smokestack, kitchen and second-class rooms, cooks' and wash rooms, etc. On the same deck there will be a forecastle about 50 feet long, divided for the crew, water closets, mate's and cooks' stores, ice houses, oil and lamp rooms, etc. The fourth deck will be covered with canvas as far forward and aft to join the caulked deck. Aft of the smokestack there will be a house 24 feet in width by 105 feet in length, containing engine-room opening, engineers' rooms, social hall, toilet room for ladies, and passenger state rooms with skylights. On this deck surrounding the smokestack there will be a house about 40½ feet long by 27½ feet wide containing smoking room, gents' toilet, passenger state rooms, officers' mess room and pantry. Forward of the smokestack there will be located a house 18 by 37 feet in the clear,

with elliptical front, to contain ten state rooms for passengers and stairs to the captain's room. On top of this house will be located a pilot house, captain's room, toilet, one state room and two officers' rooms. The new vessels are to be schooner rigged with two pole masts and wire standing rigging. In the second between decks there will be two cargo ports on each side; also two coaling ports. In the third between decks there will be three cargo ports on each side and also one air port on each side, abreast of galley. There will be three freight hatches in first, second and third decks, and two in the fourth deck; the one aft in the first deck will be double.

Power for the propulsion of each vessel will be furnished by direct, tri-compound engines with inverted cylinders, 28, 45 and 72 inches in diameter by 54-inch stroke. The crank shafts will be of scrap iron in two or three pieces, of the built-up form. The condensers will have about 5,650 feet of cooling surface and there will be equipments of air, feed and bilge pumps of the Blake pattern. The boilers, four in number, will be of the cylindrical and return-tubular type, with 14½ feet diameter of shell and a length of 12 feet inside; three furnaces will be provided, each leading into separate combustion chambers. The diameter of the furnace will be about 50 feet inside and the fire bars are not to exceed 6 feet 9 inches in two lengths. The grate surface will aggregate 320 square feet and a working pressure of 170 pounds per square inch will be developed. A Buffalo blower, direct-driven with independent engines and of 8,000 to 10,000 cubic feet capacity, will be located forward of the smokestack at a height of the main deck and arranged to draw air from the hold and also from the ventilator, and discharge overhead into the fire room; the blower will be arranged and piped complete for both steam and exhaust. The donkey boiler is to be of the Scotch type, 6 feet 10 inches in diameter by 9 feet 2 inches long and constructed for a working pressure of 170 pounds. The vessels will be equipped with Hyde steam capstan windlasses and each will have four Williamson steam hoisting engines, cylinders 8 by 8 inches. The electric-lighting plants will be similar to that installed in the *Juniata*, and every room in the vessels will be heated by steam.

The interior furnishing will be quite as elaborate as in the case of the *Juniata*. The captain's room will be paneled in light hard wood; the smoking and mess rooms will be similarly paneled and will have floors of cherry and maple, while all state rooms will have hard wood berths.

The contract for the first of these new vessels was let on May 2, 1898, and calls for her completion not later than April 1, 1899. It is stipulated, too, that on a trial trip of twelve hours duration the new vessels shall develop an average speed of 16 knots, which is one knot in excess of the speed developed by the *Juniata* on her trial.—"Marine Review."

Statendam.—On September 18 the new steamer *Statendam*, built by Messrs. Harland & Wolff, Limited, to the order of the Holland-American Line, left the Alexandria wharf and proceeded down the lough for trial and adjustment of compasses. This steamer has a gross tonnage of about 10,400 tons, her dimensions being: Length, 515 feet; breadth, 59 feet 6 inches; depth, 43 feet 6 inches. She will be propelled by two sets of engines constructed by the builders in their usual style. She is also equipped with a full installation of electric-light and refrigerating machinery, and all the latest appliances for rapid handling of cargo and general efficient working of the ship. Accommodation is provided for a large number of passengers, for whose comfort every convenience has been fitted, the vessel being tastefully decorated in cabins and saloons, which are large and airy, and in the builders' usual handsome style. This ship is intended for the trade between Rotterdam and New York, also with her sister ship, *Rotterdam*, also lately built by the same firm. After a very successful trial the steamer left to take her station on above-mentioned route.—"Marine Engineer."

Launches and Trial Trips.—Messrs. Alexander Stephen and Sons, Linthouse, launched on the 1st of September a steel screw steamer, built to the order of Sir Christopher Furness for the Hamburg-American Company. Her length is 500 feet, and she has a cubic measurement cargo capacity of nearly 20,000 tons. The upper and main decks are of steel, all fore and aft. There is a shelter deck extending all fore and aft with special

strengthening for Atlantic weather. This deck is fitted throughout for carrying cattle. Further cattle space is provided on an upper bridge about 120 feet long. The vessel will carry about 900 head of cattle in all. The accommodation for captain and officers is provided for in large deck houses on the upper bridge, while the seamen and firemen are located on upper deck forward, and the cattlemen on the same deck aft. The portion of the double bottom under the machinery space is subdivided and arranged for carrying fresh water for cattle, with all necessary pipes, connections, etc., for distribution throughout the cattle spaces. No fewer than fourteen powerful steam winches and thirty derricks are provided in order to secure the most convenient and rapid handling of cargo. Her engines will have cylinders, 30 inches, 50 inches and 83 inches in diameter by 60-inch stroke, with four boilers fitted with Howden's forced draft, and working at 180 pounds pressure. The ship was named the *Bengalia*.—"Engineering."

Bosnia.—On August 18 there was launched from the Jarrow yard of the Palmer's Ship-building and Iron Co., Limited, the largest cargo and cattle steamer hetherto launched from their yard (although battle ships of greater dimensions have been built at Jarrow), to the order of Sir Christopher Furness, for the Hamburg-American Co. Her length over all exceeds 500 feet, her displacement is about 16,500 tons, and she has a measurement cargo capacity of 19,250 tons. The vessel is constructed of steel, and has been built under special survey to class 100 A1 in Lloyd's Registry. She is fitted with a straight stem and elliptical stern, and will be rigged as a four-masted fore-and-aft schooner. Spacious accommodation for passengers, captain, officers, engineers, petty officers, etc., is provided in large steel deck houses on the shade deck, alongside of, and forward and aft of the engine and boiler casings. The seamen and firemen are berthed on the upper deck forward, and the cattlemen on the upper deck aft. The upper and main decks are of steel, and extend all fore and aft. A wood deck is laid in the forehold. The shelter deck, sides and deck extend all fore and aft, and is specially strengthened for the Atlantic trade. The 'tween deck is

left clear and fitted throughout with the most improved and modern arrangement for carrying about 900 head of cattle. Additional cattle space is also provided and fitted up in a shade deck, which extends about 130 feet over the midship part of the vessel, and encloses the engine and boiler openings. The sides are constructed of steel, and are enclosed, and the deck is of wood.

The vessel is divided into eight water-tight compartments by means of seven steel bulkheads, all of which extend to the upper deck. Each cargo compartment is fitted with a complete set of grain-division boards, extra large cowl ventilators, and all other requirements for the safe carriage of grain or other cargoes, and a complete system of hatches, winches and derricks is provided for the rapid loading and discharging of cargoes. A powerful steam windlass is fitted forward for working the cables, and a combined hand and steam screw-steering gear of special design is fitted in a large steel wheel house on the after end of the shelter deck. The vessel is lighted throughout by electricity, and will be fitted and finished as a first-class cattle and cargo steamer, including all the most modern improvements, for the Atlantic trade. Ample water ballast is provided in a cellular bottom, which extends all fore and aft, also in a deep tank extending to the main deck, fitted abaft the engine room. The after peak is also fitted as a trimming tank. The vessel will be fitted with triple-expansion engines, having cylinders of 30 inches, 50 inches and 83 inches by 60-inch stroke, and with four boilers, having eighteen furnaces in all, constructed by the Palmer's Co.—"Marine Engineer."

Trigonia.—This steamship was taken for trials at sea on the 26th September, when she made an average speed of 10 knots. This is the first of two vessels being built on the trunk system by Messrs. Armstrong, Whitworth & Co., for Messrs. M. Samuel & Co., of London. Her dimensions were given in the August number of the JOURNAL. The bunkers of the vessel are made air tight and specially stayed so as to contain oil fuel, and are also available for coal in case of emergency. The sea trials

were made with both liquid fuel and coal, and were very satisfactory.

Mount Royal.—On August 17, there was launched from the ship-building yard of Messrs. C. S. Swan & Hunter, Limited, Wallsend-on-Tyne, the cattle and cargo steamer *Mount Royal*, which has the following dimensions: Length over all, 483 feet; length between perpendiculars, 470 feet; beam, extreme, 56 feet; depth, molded to shelter deck, 42 feet 10 inches. The engines, built by the Central Marine Engine Works, of West Hartlepool, have cylinders, 28 inches, 46 inches and 75 inches in diameter by 54 inches stroke, and are capable of giving 28,000 indicated horse power. Steam is supplied from three large single-ended boilers, fitted with Howden's forced draft. The steamer will carry a deadweight cargo of 11,000 tons on a draught of water of 27 feet, and a measurement cargo of 18,000 tons.

Omrah.—The new mail steamer *Omrah*, for the Australian trade of the Orient Steam Navigation Company, Limited, was launched by the Fairfield Ship-building and Engineering Company, Limited, on Saturday, September 3. The dimensions are as follows: Length over all, 510 feet; length between perpendiculars, 490 feet; breadth, 56 feet 9 inches; depth, 37 feet, 6 inches; gross tonnage about 8,650 tons, and indicated horse power about 8,500. The vessel has a straight stem and elliptical stern, and has five decks, with poop, 90 feet, forecastle, 70 feet, and a continuous promenade deck, 275 feet in length. Above the promenade deck and extending 50 feet over the poop there is a boat or shelter deck, 184 feet long, on which provision is made for carrying the boats, sixteen in number. A cellular double bottom is fitted the full length of the ship, and the holds subdivided into separate compartments by water-tight bulkheads, which are arranged and constructed to meet the recommendations of the Bulkhead Committee, with strong collision bulkhead fitted forward. The holds have been so subdivided that even if two of the largest of them were filled with water the vessel has sufficient surplus buoyancy to enable her to keep afloat. She is fully qualified for employment as an armed cruiser, and her name will be placed on the Admiralty list for this purpose.

She will have one large funnel, and two pole masts fitted with derricks and fore-and-aft sails.

When completed the vessel will have accommodation for about 330 first and second-class passengers berthed on the main and spar decks, also for 500 third-class passengers who can be berthed on the lower deck. The cabin accommodation is of the most comfortable description, the state rooms being arranged for two, three and four persons. In several of the cabins the lower berths are fitted so as to draw out and make double berths. The fittings are all of the most modern and approved style and best quality throughout. The first-class entrance is in the forward part of the ship on the promenade deck, and leads direct to the dining saloon, a spacious room on the spar deck, lighted by a skylight and well from the boat deck, and by large, square windows in the sides. Immediately forward of this entrance the drawing-room is arranged, with writing rooms adjoining. The first-class smoking room is situated aft of the saloon well on the promenade deck, fitted with all the latest improvements, and can be entered direct from the dining saloon without going out on the promenade deck, which will be a great advantage to passengers in rough weather. The second-class entrance is built on the poop deck, and leads to the second-class dining saloon on the main deck. Aft of this entrance is the second-class smoking room, fitted in a similar manner to the first class. An extensive library will be supplied for the use of the first and second-class passengers, and a grand piano will be placed in the drawing room, also an organ in the first-class dining saloon, and a piano in the second-class dining saloon.

There will be a very large refrigerating plant with insulated chamber for the storage of meat, poultry, milk, fruit, etc., also wine and vegetable rooms. The machinery will consist of two sets of triple-expansion engines, each set having three cylinders. The high-pressure cylinders are each fitted with a piston valve, the medium and low-pressure cylinders having ordinary flat slide valves, all worked by the usual double-eccentric and link-motion valve gear. Each reversing gear is controlled by a combined steam and hydraulic reversing engine. The crank shaft is

in three pieces, and all the shafting is of forged mild steel. Each screw propeller has four blades of manganese bronze, the boss being of cast steel. The boilers for generating the steam for the engines are five in number, viz: three double-ended and two single-ended, of the ordinary multitubular marine type, and arranged to work with Howden's forced draft. Each of the double-ended boilers has eight furnaces, and each of the single-ended four, making a total of thirty-two furnaces, the products of combustion being led into one funnel. The boilers are constructed entirely of steel and adapted for a working pressure of 180 pounds per square inch. There will also be an auxiliary boiler for supplying steam to the donkey pumps, fresh-water condenser, galleys, etc.

Atlantic Records.—The performance of the *Kaiser Welhelm der Grosse* is again causing Atlantic records to be printed. The first steamship to cross the Atlantic was the *Savannah*, which made the run from Savannah to Liverpool in twenty-nine days and eleven hours. That was in 1819. Beginning in 1852, the records were made between New York and Queenstown, and the best of them, east or west, are shown in the appended table:

		D.	H.	M.
1856.	*Persia*,	9	13	41
1856.	*Persia*,	9	1	45
1863.	*Scotia*,	8	3	0
1869.	*City of Brussels*,	7	22	3
1873.	*Baltic*,	7	20	9
1875.	*City of Berlin*,	7	18	2
1875.	*City of Berlin*,	7	15	28
1876.	*Germanic*,	7	15	28
1876.	*Britannic*,	7	13	11
1876.	*Britannic*,	7	12	47
1877.	*Germanic*,	7	11	37
1877.	*Britannic*,	7	10	53
1879.	*Arizona*,	7	8	11
1882.	*Alaska*,	7	6	43
1882.	*Alaska*,	6	22	10

		D.	H.	M.
1884.	*America*,	6	14	8
1884.	*Oregon*,	6	9	42
1885.	*Etruria*,	6	5	36
1887.	*Etruria*,	6	4	36
1888.	*Etruria*,	6	1	55
1889.	*City of Paris*,	6	0	29
1889.	*City of Paris*,	5	23	38
1889.	*City of Paris*,	5	19	18
1891.	*Teutonic*,	5	16	31
1892.	*City of Paris*,	5	14	24
1893.	*Campania*,	5	12	7
1894.	*Lucania*,	5	7	23

The *Kaiser Wilhelm der Grosse* is not in this list, as her recent record-breaking voyage was between Southampton and New York, and cannot well be compared with the New York and Queenstown run.—"Marine Review."

The four Admirals.—Within the last six months the keels have been laid and the hulls built and launched at the Cramps' Yard in Philadelphia of four steamers, *Admiral Dewey*, *Admiral Sampson*, *Admiral Schley* and *Admiral Watson*, for trade between Jamaica and Boston or Philadelphia. These steamers will furnish a weekly mail service to Jamaica and intermediate ports. They are built especially for the fruit trade, and are essentially similar.

The following general dimensions are given for the *Dewey*.

The *Admiral Dewey* is a twin-screw steel steamer, 292 feet in length over all, 36 feet breadth of beam and 18 feet depth of hold, and 2,000 tons capacity. She is of cellular construction and her engines will develop 2,500 horse power. They are of triple-expansion type. The guaranteed speed is 15 knots an hour. She has two steel tubular boilers. She has accommodations for 75 first-class passengers on the main and shade decks. A system of induced ventilation for the cargo is one of the equipments that make her especially valuable for the fruit trade. The *Dewey* and her sister ships, it is said, will be the finest ships in the West Indian trade. The plans of the four steam ships have

been approved by the United States Government, and they will carry the mails. They are constructed so as to be readily converted into cruisers, having mounts for four 5-inch guns.

New Steamer for Porto Rico Trade.—The Harlan and Hollingsworth Co. has signed a contract to build for Miller, Bull & Knowlton, of New York city, a single-screw freight and passenger steamer for the New York and Porto Rico Steamship Co. The vessel will be built to the highest rating accorded by the American Shipmasters' Association. The dimensions are as follows: Length over all, 335 feet; length on L.W.L., 322 feet; length from fore side rudder post to aft side stem, 317 feet; beam molded, 42 feet; depth molded at center to main deck, 19 feet 10 inches; depth molded at center to spar deck, 27 feet 8 inches; depth at side to spar deck, 26 feet 7½ inches; draught, loaded, 19 feet; camber main deck, 10 inches; camber spar deck, 10½ inches. The engine is to be tri-compound, with inverted cylinders, 24, 28 and 62 inches, with a stroke of 42 inches. The vessel will be thoroughly fitted out with an electric-light plant, six water-tight bulkheads, and equipped with dining rooms, state rooms, bath rooms, smoking rooms, card rooms, etc., of the most recent design, and fitted in every particular for the American-Porto Rican trade.—"Seaboard."

The Largest Cargo Carrier.—The Hamburg-American Line has placed an order with Blohm & Voss, ship-builders of Hamburg, for a new twin-screw steamer which will be the largest cargo carrier in the world. Her dimensions are 600 feet on the water line, 66 feet beam and 42 feet depth. The total capacity for cargo, exclusive of coal, etc., will be about 20,000 tons of 40 cubic feet. There will be ample accommodations for 300 first-cabin passengers, 200 in the second cabin, and berths for 600 steerage passengers. The general arrangement of the passengers' quarters will be about the same as on the *Pennsylvania* and *Pretoria*, of the line, although the interior decorations will be more elaborate.

But what will distinguish this new steamer from any other afloat will be a feature which has as yet never been introduced in the construction of a merchant vessel. To insure the safety

of passengers in case of collision, the directors of the Hamburg-American Line, to make this new steamer as nearly as possible unsinkable, have, besides numerous water-tight bulkheads, double bottoms, etc., provided for double sides. The space between the outer and the inner skin will form water-tight compartments, so that in case of collision only this outer part of the ship will fill with water, leaving the rest intact. This arrangement will make an almost ideal safeguard against consequences of a serious accident.—"Marine Record."

Haliotis.—The launching notice of this steamer, in the May number of the JOURNAL, included a statement regarding the intention of using oil fuel. The following account of her trial is taken from "Engineering."

The S.S. *Haliotis* was taken for trial at sea on the 3d September, when she made an average speed of 10.6 knots. This is the second of two vessels built on the trunk-deck system by Sir W. G. Armstrong, Whitworth and Co. to the order of Messrs. M. Samuel and Co., of London. Her dimensions are: Length, 248 feet 6 inches; breadth, 40 feet; and depth, 17 feet 8 inches. The engines are of the compound surface-condensing type, taking steam from two boilers working at 100 pounds pressure, the diameter of the cylinders being 30 inches and 63 inches, with a stroke of 39 inches. Both engines and boilers have been specially designed and constructed under the supervision of Messrs. Flannery, Baggallay and Johnson, of London and Liverpool. The ship is intended to burn liquid fuel on her service in the East, and her engines and boilers have been fitted out with a special view to this. Electric light is fitted throughout the ship, and there is a complete installation of duplex pumps for the rapid dealing with oil cargo. The bunkers are made oil tight and especially stayed so as to contain oil fuel, and are also available for coal in case of emergency. The above trial was made with coal, and was very satisfactory.

On the arrival of the vessel in London an extended trial with oil fuel was made, and the various data and consumptions under the two systems carefully compared. This trial took place on the 13th September, on the Thames below Gravesend. Among those

on board was Sir John Durston, K. C. B., Engineer-in Chief of the Admiralty, Sir Marcus Samuel, Mr. Fortescue Flannery, M. P., under whose direction the work has been executed, Colonel Swan, Mr. G. W. Manuel, chief engineer of the P. and O. Company, together with representatives from many of the leading steamship companies trading to the East. From the bunkers the oil is pumped to a service tank above the boilers, whence it flows by gravity to a device at the furnace doors, where, by means of a steam jet, it is "pulverized" or broken into spray. Its combustion is carried out without any layer of incandescent coal such as is sometimes employed with liquid fuel. In trials with the *Haliotis* it has been found that 2.27 pounds of ordinary north-country coal were used for each indicated horse power per hour, as compared with 1.67 pounds of oil, and in the Eastern trade, where steamers have to rely on inferior Japanese and Indian coals, the comparison must work out still more in favor of the liquid fuel. For example, a boat requiring a minimum of 500 tons of coal for her voyage from Aden to Singapore would have an ample fuel supply with 300 tons of oil, thus largely increasing her cargo capacity.

Another advantage is the speed with which fuel can be taken on board. While the rate at which coaling is performed does not, as a rule, exceed 60 or 80 tons an hour, 400 tons of oil can be pumped into the bunkers in the same space of time. Then, again, an immense saving of labor is claimed with the use of oil fuel. Once the burners are regulated, the supply goes on automatically, and it is said that a whole voyage may be performed without once opening the furnace doors. Hence, the number of stokers is greatly reduced, and, it may be added, those that are required work under much more pleasant and healthy conditions, owing to the absence of coal dust in the stokeholds. When the furnace is in full blast there is very little, if any, smoke produced —a point which might commend the system for use in men-of-war, while the fact that oil can be stowed in places which are not practicable for coal bunkers, suggests that its use might ease matters a little in the closely-packed interiors of torpedo-boat destroyers. Of course, liquid fuel has its disadvantages. The

steam used in the burners involves a serious loss of fresh water —an important item on an ocean-going steamer—and it is not pretended that the direct cost in this country, under present conditions, is so low as that of coal, whatever may be the case in a region like that of the *Caspian*, where the steamers are all fired with petroleum refuse burnt in much the same way as on the *Haliotis*. And in connection with its use for the Navy, one fact of supreme importance must be remembered. None of the great petroleum fields of the world are on British territory or under British control, and it would obviously be sheer folly to make our ships depend on a fuel the supply of which could not be absolutely assured.

Russian Ice-Breaking Steamer.—The following additional details of this vessel, the construction of which was noted in the August number of the JOURNAL, are interesting. The extract is from "Engineering:"

Messrs. W. G. Armstrong, Whitworth and Co., Walker-on-Tyne, launched on Saturday afternoon, the 29th October, an ice-breaking steamer, said to be the largest in the world, which the firm has built for the Russian Government. The vessel is the pioneer ship of what may be termed pelagic ice breakers. The dimensions and appearance of the vessel would suggest a battle ship were it not that the bow is cut away and forms an exceedingly long overhang, which serves the double purpose of breaking the ice with which it comes in contact and of protecting the forward propeller. The forward propeller, by disturbing the water under the ice, deprives it of its support, and then renders it a comparatively easy task for the heavy vessel to break through it. The principal dimensions are: Length, 305 feet; breadth, 71 feet; and depth, 42 feet 6 inches. When fully loaded the draught will be 25 feet, and the corresponding displacement 8,000 tons. The propelling machinery, which has been constructed by the Wallsend Slipway and Engineering Company, has been divided into four sets, of which three sets are aft, each driving its own propeller, and one set forward. The combined power of these four sets of machinery will be 10,000 horse power. There is accommodation for thirty first-class passengers, ten second-class and

fifty third-class passengers, besides that for the captain, officers, engineers and crew of the vessel. There is ample capacity for cargo, so that the vessel, in addition to convoying merchant vessels through the ice, is herself capable of carrying a heavy cargo. The stern of the ice breaker is cut to form a recess, into which the stem of another vessel can be securely lashed, and thus obtain the utmost protection from her powerful consort. Admiral Makaroff has also in view the possibility of augmenting the ice-breaking capabilities of this vessel by having the assistance of a second vessel pushing her, as to which he has already made experiments.

Yawata Maru.—This steamer, built for the Japan Mail Service by Messrs. R. Napier and Sons, Limited, Govan, has just completed a series of speed and consumption trials on the Firth of Clyde, and although the weather was very severe, all the conditions of the contract were fully implemented. The *Yawata Maru* is the third of three similar steamers the builders have constructed, specially designed to suit the requirements of the company's Japan and Australian service. The general dimensions are: Length, 375 feet; breadth, 44 feet; depth, 27 feet 8 inches, with a top-gallant forecastle, long bridge, full poop, and partial shade deck, on which the boats are stowed, and which makes an admirable shelter to the spacious promenade on the bridge. Refrigerating machinery and chambers are fitted for frozen meat. Accommodation has been provided amidships for the first-class, and as the steamers are intended to trade in tropical climates, the commodious state rooms have been placed on the upper deck, which admits of perfect ventilation, and are furnished with the most recent improvements for the comfort of the passengers. Above, on the bridge deck, are dining saloon, music room and smoking room, finished in polished oak, and supplied with swivel side lights, electric fans, etc., the ventilating arrangements having had special attention. The second-class accommodation is in the poop, with a large dining saloon, comfortable smoking room, and roomy cabins; commodious quarters for emigrants are in the 'tween deck, and the officers are berthed on the boat deck beside the chart room. The machinery consists of a set of triple-expansion

engines, having cylinders, 29 inches, 48 inches and 79 inches in diameter by 54-inch stroke, with two double and one single-ended boiler for a working pressure of 185 pounds. The results were very satisfactory, the contract speed being more than maintained, while the consumption of coal was considerably less than that guaranteed.—"Engineering."

Nippon Maru.—On August 20 this steamer was taken on her official trial on the measured mile at sea, when she made an average speed of 16¼ knots, and engines worked in a very satisfactory manner. This vessel is one of the first of a fleet of twin-screw mail and passenger steamers being built to the order of Messrs. M. Samuel, of London, on behalf of the Tokio Kiser Kabushiki Kaisha, of Tokio, Japan, and has been built by Sir James Laing, of Sunderland. Her length is 441 feet, depth, molded, 22 feet 6 inches, breadth, 50 feet 6 inches. The engines, by Messrs. George Clark, are in duplicate, with cylinders, 28½ inches, 46 inches and 75 inches in diameter, with a stroke of 48 inches, and are driven by four double-ended and one single-ended boiler, which give a total heating surface of 20,000 square feet. This vessel has been built under the direct supervision of Messrs. Flannery, Baggallay and Johnson, of London and Liverpool, with whom is associated Captain Tomioka, the owners' representative in this country. This vessel is built to Lloyd's highest class, and has all the latest improvements for this class of vessel, the passenger accommodation being fitted up in a most luxurious manner, and is arranged to carry eighty-nine first-class and twenty-eight second-class passengers and servants, and 200 emigrants. After the trial the vessel returned to the Tyne, to partially load before leaving for London.

YACHTS.

Widener's New Yacht.—P. A. B. Widener, of Philadelphia, has ordered of a Delaware River ship builder, a pleasure yacht, which, it is believed, will be one of the handsomest owned in America. It will be remembered that at the breaking out of the war with Spain Mr. Widener sold his yacht, the *Josephine*, to the Government, and that she won distinction under her new name, the *Vixen*. The yacht now contracted for is to supply for Mr. Widener the place of the *Josephine*.

She will cost in the neighborhood of $400,000, and is expected to be finished in ten months. She will have a length over all of 257 feet, on the water line, 216 feet, and will have 30 feet 3 inches beam. From base line to main-deck beams she will be 18 feet 6 inches, and 26 feet 6 inches from base line to top of awning-deck beams.

The bridge extends across the boat, with wheel, compasses and chart table. Under the bridge will be the chart room, and aft the captain's room, extending the width of the house, 12 feet. Next aft on the upper deck will be the library, 26 by 12 feet. Over this apartment will be an elliptical skylight for ventilation, and a dome. The engine-room skylight will be aft the library, and the remainder of the upper deck will be given up to a promenade, 145 feet in length.

At the forward end of the space under the bridge will be the owner's rooms, each 19 by 15 feet. Aft of each will be a bath room. Between the bath rooms a stairway will extend to four lower guests' rooms. From the stairs a passageway will lead to the dining room, whose dimensions will be 30 feet 6 inches by 16 feet. Aft, on the starboard side, will be the reception room, 29 by 9½ feet, extending half the yacht's width, and over the engine room. It will be finished in antique oak, paneled.

At the after end of the ladies' room will be a mahogany stair-

case leading to the owner's quarters below, and at the foot of the stairs two large state rooms. Aft, on the starboard side, there will be a state room with two berths. Further aft will be three more state rooms. Then come the owner's bath rooms and the maid's quarters, the latter containing four berths, and extending across the yacht. Forward of the foremast, on a drop of two feet, will be the crew's airing space. Under this deck is the crew's galley, mess room and pantry. On the deck below is the crew's forecastle and quartermaster's room. Aft are trunk and storage rooms.

The new yacht will have all of the latest improvements in equipment. Her machinery will consist of a quadruple-expansion engine, with cylinders, 19½, 28, 39 and 57 inches in diameter and 36 inches stroke. The power will be sufficient to drive the yacht at least 17 knots per hour in ordinary weather. The coal-bunker capacity will be 240 tons. Capt. S. G. Chase, commander of the former *Josephine*, will command the new yacht, and, with Mr. Widener, will supervise her construction.

Two Up-to-Date Yachts.—The great number of steam yachts sold to the Government at the beginning of the recent war has resulted in considerable activity in the matter of the awards of contracts for new vessels of this class. Two yachts which embody in their design ideas that indicate the highest development of modern yacht construction are now building at the works of the Gas Engine and Power Co. and Seabury & Co., Consolidated, of New York. The first of these yachts is for Mr. John P. Duncan, of the New York Yacht Club, and was designed by Mr. Charles L. Seabury to replace the *Kanawha*, which Mr. Duncan sold to the Government. The boat now on the stocks is 225 feet over all, 192 feet on the water line, 24 feet beam, 14 feet depth and 10 feet draught, loaded. According to the stipulations of the contract, the vessel must maintain a speed of 20 miles per hour during a trial of two consecutive hours. The frames will be of angle steel, spaced 23 inches, and will be 3½ by 3 inches in size through the main body of the yacht and 3 by 2½ inches through the forward and after sections. Reverse frames, also of angle steel, will be 3 by 2 inches through the main body, and 2½ by

2 inches in sections forward and aft. The plating is to run in fair lines with in and out strakes below the water line, the horizontal seams being lapped, and above the water line it is to run flush with inside straps. All riveting will be double, and there will be four water-tight bulkheads running in one length from floors to deck beams wherever possible. The deck will be of clear, well-seasoned white pine. The yacht will have three masts, and the water tanks in the hull will have a capacity of 6,000 gallons. There will be two deck houses of steel, one 40 feet and the other 24 feet in length. The yacht will be equipped with two triple-expansion engines, with cylinders, 14, 23¾ and 43 inches in diameter by 24-inch stroke. Two electric-light engines, capable of generating power for 150 sixteen-candle-power lights, will also be provided. Four Seabury water-tube boilers, capable of a working pressure of 250 pounds per square inch, will be fitted, and there will be a small boiler for furnishing steam for the electric-light plant and for the evaporator, which will have a capacity of evaporating and condensing 1,200 gallons of water in twenty-four hours.

The other yacht, upon which work has just been commenced at the same yard, is for Louis Bossert, of Brooklyn, N. Y., the owner of the steam yacht *Mayita*, built by the same firm several years ago. The new craft will be 135 feet over all, 110 feet water line, 16 feet beam, 9 feet 6 inches depth, and 6 feet 6 inches draught. The hull will be of composite construction, with steel frames, deck timbers, clamps, keelsons, etc., and yellow-pine planking. The vessel will be of the flush-deck type, schooner rigged. Forward there will be a deck house 26 feet in length. The machinery installation will consist of Seabury triple-expansion engines, with cylinders, 8½, 14 and 23 inches by 12-inch stroke. The boiler will be of the Seabury water-tube type, and allowed 260 pounds working pressure. The guaranteed speed of the vessel will be 16 miles. Both vessels are to be completed in time for use next spring.—"Marine Review."

A. E. Tower's New Yacht.—The Delaware River Iron Shipbuilding and Engine Works (Roach's Shipyard) will build a new steam yacht for A. E. Tower, of Poughkeepsie, N. Y. The new

vessel was designed by Messrs. Gardner & Cox, of 1 Broadway, New York, and will be used by the owner in long cruises, his purpose being to cross the Atlantic and remain in European waters for some time just as soon as his new craft is ready. She will be 160 feet in length on the water line, 23 feet beam, and 10 feet draught. The motive power will consist of two modern four-cylinder engines, which will develop 2,000 horse power and will drive twin screws. Steam will be supplied by four water-tube boilers of the Almy type, manufactured by the Almy Water-tube Boiler Co., of Providence, R. I. A speed of 19 knots is guaranteed by the builders. The owner's quarters are to be on deck in the forward house, and will consist of two large state rooms, with bath and dressing rooms, these being finished in mahogany, with the exception of the bath room, which will be in glazed tiling. The after deck house has, in the forward end, the dining saloon. Next to this is the smoking room, which will be finished in old English oak and upholstered entirely in leather. Aft of this again is the steward's pantry, which is a passageway connecting with the dining room, and also with the galley, in the after end of the house. Below deck, forward, are the guests' quarters, consisting of four state rooms, a large bath room and large main saloon. Aft of the engine and boilers will be the bachelors' quarters, consisting of three spacious state rooms and bath room. These rooms are entirely separate from the guests' quarters forward. The yacht will be lighted with electricity throughout, including a powerful search-light, and will be equipped with an ample storage battery to run the entire plant when the vessel has no steam.—"Seaboard."

BOOK REVIEWS.

STEAM.—The Babcock & Wilcox Company of New York have issued a new edition of their publication, "Steam," wherein, besides the usual matter relative to their own particular generators, a very great deal of useful and up-to-date information for steam users will be found. The book is handsomely gotten up, and the general arrangement of the tables and special notes is such that they may be readily referred to without the necessity of wading through a mass of obtrusive advertisements. We understand the book is distributed gratis among those interested, and undoubtedly the Babcock & Wilcox Company will appreciate application for a copy especially from owners or operators of steam plants.

PAINTING ON METAL, WITH SPECIFICATIONS. BY A. H. SABIN, M. S.—Published by Edward Smith & Co., 45 Broadway, New York.

This little book, we are informed, is to be placed on sale at a retail price of $1.25, but as its character is very much like the book on steam, just reviewed—*i. e.*, a very useful and ornamental setting for the advertising of a specialty—it is scarcely possible that it can elevate itself into a position where it will be sought for at the price. The final chapter "Conclusion," which is a reprint from the "Troy Polytechnic," is interesting reading, and contains the "meat" of the book. The subject of painting on metals is one upon which too little actual knowledge is possessed by the mass of inspectors of such work, and the information contained in the volume noted is of much practical value.

OBITUARY.

GEORGE R. JOHNSON.

Chief Engineer George R. Johnson, U. S. Navy (retired), died in Washington, on the 16th of October, of *angina pectoris*, after having been confined to his bed for almost a year.

Mr. Johnson was born in Norfolk, Va., in 1828. He learned the trade of machinist in that city, and became so proficient that he passed the line at which the ordinary mechanic ends and the artist is recognized.

He entered the Navy as a Third Assistant Engineer in 1852, and served on board the *Princeton*, the first very successful screw steamer in the Navy. He was on special duty at Norfolk in 1855, was promoted to Second Assistant Engineer in this year, and served on board the steam frigate *Merrimac* in 1856 in the Mediterranean. He was ordered to the *Roanoke* in 1857, and also served on board the *Niagara* when she laid the first cable across the Atlantic. On this occasion he was the principal dependence of the Chief Engineer (Mr. Everett), who invented the paying-out gear.

Mr. Johnson was promoted to First Assistant Engineer in 1858, and served in the office of the Engineer-in-Chief until 1861, when he was promoted to Chief Engineer and ordered to the *Lancaster*, where he remained until 1864. From 1864 to 1867 Mr. Johnson was employed as inspector of the machinery of the iron clads building at Wilmington, Del., and from 1869 to 1870 he served on board the *Dictator*. From 1872 to 1874 he was Fleet Engineer of the Pacific Squadron, and from 1874 to 1877 was superintendent of construction of the monitor *Amphitrite*. From 1877 to 1879 he was Fleet Engineer of the South Atlantic Squadron. From 1879 to 1884 he had special duty at Wilmington. He was Fleet Engineer of the European Squadron 1884–1886, and from 1887 to 1890 he was superintending the construction of the ma-

chinery for the *Petrel* and other vessels at Baltimore, Md. Mr. Johnson was retired on the 9th of November, 1890.

He was a man of rare ability, and, while an abstemious man in his habits, he was thoroughly sociable and a "good shipmate," and always had a host of friends.

HUGH HADAWAY CLINE.

Chief Engineer Hugh Hadaway Cline, U. S. Navy (retired), was born in Baltimore, Md., September 3, 1837, both his parents being native-born Americans, his father, Jacob Christian Cline, having been born in Hagerstown, Md., while his grandfather on his father's side came over from Germany (Prussia) with Baron Steuben and fought under Washington in the Revolution. His mother was born at St. Michael's, Md., her maiden name being Sarah Auld, and her father, Colonel Hugh Auld, rendered distinguished services in the War of 1812–15.

Mr. Cline was educated in the public schools of Baltimore, Md., and graduated with honor from the High School, Baltimore, Md., at the age of sixteen years.

He then served an apprenticeship as a pattern maker at Ross Winan's Works in Baltimore, working hard during the day, and studying at night up to 3 A.M. for his subsequent profession of engineering.

After serving his time as apprentice, he worked as journeyman for a year, when by hard work and economy he saved enough money to pay for instruction on the steamboat *Virginia* in the practical work of an engineer, but while on the *Virginia*, the boat was seized by the Confederates, Chief Engineer Cline escaping by going on board of a schooner and working his passage home.

After successfully passing the required examination, he was appointed from Maryland as Third Assistant Engineer, July 1, 1861, and reported on board U. S. flagship *Lancaster* for duty August 22, 1861; on board U. S. S. *Wyoming* from September 6, 1861, to July 23, 1864; warranted Second Assistant Engineer December 18, 1862.

Mr. Cline was on experimental duty, navy yard, New York, from August 18, 1864, to July 10, 1865; on U. S. monitor *Dictator* from July 10, 1865, to September 5, 1865; on U. S. steamer *Pensacola* from October 26, 1865, to April 19, 1869. Commissioned First Assistant Engineer on January 1, 1868; on U. S. monitor *Miantonomoh* from November 11, 1869, to May 27, 1870.

He was on the U. S. monitor *Terror* from December 2, 1870, to January 21, 1871; on U. S. monitor *Dictator* from January 21, 1871, to June 28, 1872; on U. S. steamer *Canandaigua* from October 2, 1872, to November 23, 1873. Commissioned Passed Assistant Engineer February 24, 1874; ordered to U. S. flagship *Hartford* October 2, 1874; on U. S. steamer *Hartford* November 20, 1874; on U. S. steamer *Saco* from November 20, to December 2, 1874; on U. S. steamer *Yantic* from December 2, 1874, to January 25, 1876; on U. S. steamer *Saco* from January 28, 1876, to July 13, 1876; on U. S. monitor *Wyandotte* July 24, 1877, to July 28, 1877; on U. S. monitor *Passaic* July 28, 1877, to January 2, 1880; on U. S. steamer *Swatara* from January 6, 1880, to December 15, 1882; on duty at Mare Island Navy Yard from September 17, 1883, to May 25, 1885; on U. S. steamer *Hartford* May 26, 1885, to June 3, 1885; on U. S. steamer *Mohican* from June 4, 1885, to August 21, 1888. Commissioned Chief Engineer December 2, 1887, and it is worthy of remark that he was the first who was examined under what was then an entirely new and rigorous examination for Chief Engineer, but he succeeded in passing with honor; reported for duty on U. S. receiving ship *Franklin* April 17, 1889; detached November 10, 1891, and ordered to U. S. S. *Atlanta* November 13, 1891; detached from *Atlanta* and reported for duty on U. S. S. *Charleston* July 20, 1893; and was recommended by a Board of Medical Survey to be sent home June 4, 1894. Arrived home July 13, 1894, examined by Retiring Board July 26, 1894, and as a result was placed upon the retired list for disability incurred in the line of duty and as an incident of the service August 27, 1894, after a sea service of nineteen years and two months, and shore service of seven years and eleven months.

In the latter part of July of this year, Chief Engineer Cline be-

gan to be troubled by what was supposed to be an ulcer on the tongue, but after undergoing medical treatment for nearly six weeks, no relief was experienced, and the trouble grew worse. On the night of August 31, a severe hemorrhage took place, and the serious nature of the case was recognized. Numerous surgeons and specialists were consulted, both naval and civilian, and the general verdict, confirmed by two microscopic examinations, was that a cancer was the malady and an operation was the only hope of relief held out. The danger of the operation itself was extreme, but Mr. Cline, for the sake of his wife and son, decided to undergo the operation, grave and critical as it would be. On Monday, September 26, the operation was performed. Mr. Cline, although in a very weak and exhausted state, went through it with fortitude and courage. Great hopes were entertained until the following Tuesday, eight days after, when it was found that septic pneumonia had set in. On Wednesday morning, October 5, the final moment came.

Mr. Cline was a man of the most correct habits, strictly temperate and of an unblemished moral character, while to his generous and benevolent disposition and unfailing kindness and courtesy, all who knew him can testify.

FRANK HENRY CONANT.

Passed Assistant Engineer F. H. Conant, U. S. N., died at the Naval Academy November 16, 1898.

Mr. Conant was born in Lowell, Mass., April 5, 1859, and, following a good education in the schools of his native town, was appointed to the Naval Academy, as Cadet Engineer, October 1, 1878, being then in his twentieth year. After a successful course of study at Annapolis, Mr. Conant graduated July 1, 1884, receiving his first commission as Assistant Engineeer on that day. September 30, 1894, he received his promotion to Passed Assistant Engineer. During the active life which Passed Assistant Engineer Conant led while in the service, he cruised on nearly every station visited by vessels of the United States Navy, his

last regular sea service having been on the Pacific Station whilst attached to the U. S. steamer *Philadelphia*.

Zealous and faithful in the performance of every duty, Passed Assistant Engineer Conant applied for sea duty at once when the war with Spain was declared, and was assigned to duty on the U. S. auxiliary cruiser *Resolute* (formerly the *Yorktown*, of the Old Dominion Line), as the chief engineer of the vessel.

His service on the *Resolute* was from April 28 to August 30. A month later, September 30, orders were received assigning duty at the Naval Academy.

Passed Assistant Engineer Conant was of marked ability in his profession, and his record as an officer was of unusual excellence. He leaves a widow and two children. In his death the Navy loses a fine officer and a good engineer.

ASSOCIATION NOTES.

The next annual meeting will be held in Washington, on January 10th, 1899, but, owing to the conditions which have combined to prevent the great majority of our members from securing leisure necessary for framing such papers as would insure special interest to a meeting so closely following the war, the Council has not fully decided upon the wisdom of issuing such a general call as was given last year. In this connection the members and associates interested are requested to communicate with the Secretary of the Society, stating in what way they will be able to further the interests of such a general meeting if called.

Unless a special notice is issued later the Annual Meeting will be held as prior to last year, and without extraordinary features.

For the information of our associates, who may not understand why we have had so little written upon the war experiences from an Engineering standpoint, we would state that nearly all the ships from Cuban waters have been undergoing repairs and overhauling at navy yards ever since the cessation of hostilities, every improvement suggested by the war experience being, as far as possible, added, and all work hastened to such a degree as to make the engineer officers even busier, and their time more fully occupied, than when on the blockade.

Attention is called to the increased size of the JOURNAL for this year, it averaging nearly 100 pages more per number than the average of the former five or six years. This increase was made in pursuance of the policy of reducing the cash balance on hand in such a way as would distribute the curtail most equally to the Association, and in the most valuable form. Hereafter the size of the JOURNAL will be influenced by the income, and every endeavor will be made to retain its high standard. It will

not be possible, however, to continue issuing as great a number of pages yearly as are represented by Volume X, but the present plan is to give the benefit of any increase in receipts to our readers in this way. The press work and book quality of the magazine is markedly superior to that of former years.

There are a limited number of reprints of special articles on hand, and also reprints of the official trials of the following vessels: *Foote*, *Wheeling* and *Marietta*, *Bennington*, *Minneapolis*, *Marblehead*, *Columbia*, *Katahdin*, *Bancroft*, *Texas*, *Vicksburg* and *Newport*, *Iowa*, *Brooklyn*, *Olympia*, *Machias* and *Castine*. These can be had at the usual reprint price, by any who desire them.

Anyone desiring back numbers of the JOURNAL, by volume, should communicate promptly, especially as regards the first five or six volumes, as they will be given preference over applicants for single numbers.

The new By-Laws, as adopted by the general vote on October 13, are printed below, and in lieu of insert notices to members, associates and subscribers to whom the sections 8, 9 and 19 may apply, these sections are especially called attention to as a business point upon which the welfare of the JOURNAL greatly depends.—(Ed.)

BY-LAWS OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

1. The Association shall be known as the AMERICAN SOCIETY OF NAVAL ENGINEERS.

2. The object of the Society shall be to promote a knowledge of marine engineering and naval architecture by reading, discussing and publishing papers on professional subjects; by bringing together the results of experience acquired by engineers in all parts of the world, which, though valueless when unconnected, tend much to the advancement of engineering when published together in the JOURNAL of the Society; by publishing the results of such experimental and other inquiries as may be deemed essential to the advancement of the science; and historical events in the lives of engineers.

3. The officers of the Society shall be a President, a Secretary-Treasurer, and a Council, all of whom shall be elected annually.

4. The Society shall be composed of Members, Associates and Honorary Members.

5. Officers of the Engineer and Construction Corps of the Navy, Engineer Officers of the Revenue Cutter Service, and ex-officers of those corps shall be eligible as Members.

6. Persons in civil life whose knowledge of engineering is such that they can co-operate with naval engineers in the promotion of professional knowledge, or who are intimately connected with the engineering profession, shall be eligible as Associates.

7. The Secretary of the Navy, the Assistant Secretary of the Navy, the Chief of the Bureau of Steam Engineering of the Navy Department, all ex-Chiefs of the Bureau of Steam Engineering, the prize essayist of each year, and such other persons as the Society may elect, shall be Honorary Members.

8. Members shall be admitted upon application and payment of the annual subscription.

9. An Associate may be admitted upon application in writing and payment of the annual subscription, provided his application have the recommendation of a member, and receive the approval of a majority of the Council.

10. Associates shall be entitled to all the privileges of Members except voting and holding office.

11. To be eligible as Honorary Member the candidate must receive the unanimous vote of the Council before his name shall be presented to the Society; and the favorable vote of two-thirds of the Members voting shall be necessary for election.

12. The direction and management of the affairs of the Society, and the editing and publishing of the JOURNAL, shall be vested in a Council composed of five members, the President and the Secretary-Treasurer being members *ex officio*. The Council may appoint one of its number Librarian.

13. The President shall exercise the usual duties of that office.

14. The Secretary-Treasurer shall conduct the correspondence of the Society and its financial transactions. He shall submit an annual statement of the receipts and expenditures of the Society, which shall be audited by three other members of the Council.

15. The Council shall have authority to fill vacancies which may occur during the year.

16. Subscriptions, and all matter intended for publication, shall be sent to the Secretary-Treasurer; but no paper shall be read before the Society at the annual meeting, nor anything published in the JOURNAL, without the approval of the Council.

17. In deciding matters pertaining to the Society, none but members shall be entitled to vote; to constitute a quorum for business, nine members must be present.

18. The Society shall meet annually in the city of Washington, and at such other times and places as meetings can be conveniently arranged.

19. The annual subscription shall be five dollars, payable in advance.

20. Copies of the JOURNAL may be sold by the Society at a price which shall be fixed by the Council.

21. Absent members voting on any proposition, must state

over their signatures whether they are for or against the proposition.

22. On the first Tuesday in October, a meeting of the Society shall be held for the consideration of nominations to offices falling vacant under the rules. Nominations to office must be made in writing, and may be made by any member, whether present at the meeting or not. The consent of the nominee to accept office if elected must be assured. A necessary qualification of all nominees, besides full membership, is residence in or near Washington during the term of office.

23. After the nominations are all made, lists of the candidates for the different offices shall be prepared by the Secretary-Treasurer, and mailed to all Members of the Society. Each voting list must be signed, and must show under the different offices the name of the person voted for. Each voter will enclose his ballot in a sealed envelope, which will be sent to the Secretary-Treasurer previous to the annual meeting. At the annual meeting the envelopes will be opened and the votes counted.

24. Nothing in the preceding section shall preclude the name of any candidate from being put in nomination for more than one office. In case of a tie, the presiding officer shall decide. Voting by proxy is prohibited.

25. In the event of a candidate receiving the greatest number of votes for more than one office, he shall decide which he will accept.

26. Any office falling vacant in the course of the year owing to the death, resignation or removal from Washington or vicinity of the incumbent, shall be filled by vote of the members of the Council remaining.

27. Motions to amend these By-laws, or to make new By-laws, must be in writing, and must lie over at least three months, during which time notice thereof shall be sent to all members; and the assent of two-thirds of the members voting shall be necessary to amend or adopt.